Author:
Roney, Pouneh

Title:
Not Giving Up

Not Giving Up: Academic Perseverance in Adolescence

Pooneh Roney

A dissertation submitted to the University of Bristol in accordance with the requirements for award of the degree of Doctor of Philosophy (PhD) in the Faculty of Social Sciences and Law, School of Education.

July, 2019

Word Count: 63,949 (Excluding the Cover Page, References and Appendices)

Abstract

The role of academic perseverance for predicting academic achievement and other life outcomes is widely agreed upon. Yet, there is little agreement amongst researchers on how academic perseverance is conceptualised and operationalised. The overarching aim of this research was to gain a deeper understanding of this complex phenomenon, its domain-specificity and its underlying mechanisms. More specifically, this research examined whether perseverance in mathematics can be enhanced amongst adolescents.

The research aim was addressed using two quantitative surveys (*N* = 100 and *N* = 1448) and a randomised field experiment (*N* = 152) amongst adolescents attending schools in England. Results showed that grit and self-control, as trait-level manifestations of academic perseverance, made negligible contributions explaining the variance in academic achievement (Study 1), while academic self-efficacy and mindset about intelligence positively contributed to the explanation of the variance in academic achievement (Study 2a). Mathematics-specific measures of perseverance were found superior to school-specific measures of perseverance for explaining the variance in achievement in mathematics (Studies 2b and 2c). Moreover, mastery experience in mathematics was successfully manipulated (Study 3), demonstrating impact upon self-efficacy in mathematics (with moderate effect size), effort regulation in mathematics (with moderate effect size) and performance requiring perseverant effort in a mathematics task (with large effect size), with significant mean differences between the *challenge experimental condition* and both the *success condition* and the active control group. More importantly, the findings from Study 3 demonstrated that using a social-psychological intervention, it was possible to generalise the participants’ mastery experience in a mathematics-related task to mathematics as a subject.

This research is novel in its focus on perseverance in mathematics, and in manipulating self-efficacy in order to enhance perseverance, offering support for domain-specificity of academic perseverance amongst adolescents. Findings have the potential to provide guidance for the development of educational interventions that cultivate academic perseverance amongst adolescents and to inform practice in the classroom.

Dedication

This research is dedicated to my husband Andy for his unconditional support and his belief in me and in this project. He has always indulged my intellectual curiosity at great cost to his own sanity. I am not sure he was aware what he was signing up for by encouraging me to do a PhD. He managed to hide his boredom and frustration with my obsessions during the many intense discussions about domain-specificity and grit. I cannot express my gratitude for your earnest and critical engagement with this project.

I owe my determination, perseverance and my need for learning to three amazing women: my mother, Manijeh, and my aunts, Maliheh and Tahereh. Maman you taught me that nothing is impossible. Khaleh Maliheh you taught me the importance of scientific inquiry and inspired me to be a life-long learner like yourself. Khaleh Tahereh you are the personification of perseverance.

Professor Kurt Fischer, you set me on this path and believed that my journey would be worthwhile. This is dedicated to you.

And I thank my devoted cat Oscar for his editorial contributions. You kept me going. This one is for you!

Acknowledgements

I would like to thank my supervisors Dr. Jo Rose and Dr. Shelley McKeown-Jones for their expertise, support and encouragement over the past three years. You have both challenged and supported me to go farther than I thought I could. I am grateful for your friendship and criticality in equal measures. It has been a pleasure and a privilege to work with you.

I am also very grateful to Professor Harvey Goldstein and Dr. Marcus Munafo for their advice on the statistical techniques used in this research.

This research would not have been possible, if it were not for the intrepid educators and staff in the participating schools. I wish to extend my thanks to all of you, but I am especially thankful to Leanna, Emma, Gerry and Leigh for your unwavering support for this project and your curiosity. I am grateful beyond words to Liz and Denis for providing me with the school data and for your input. You two are amazing data managers!

It has been a real privilege and a real luxury to be given the opportunity to undertake a project such as this PhD. I have learnt a great deal about perseverance and also about myself. I will forever cherish this experience and be thankful for all those who have helped me along the way and made this journey possible.

Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's *Regulations and Code of Practice for Research Degree Programmes* and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED: .... DATE: 30th April 2019

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Definition of Key Terms

The key terms applied throughout this dissertation are summarised in the table below.

Key Term	Definition
Academic Self-efficacy	A learner's beliefs about their ability to engage and complete the actions necessary for accomplishing a given academic task.
Cognitive Ability Test (CAT)	A test of cognitive ability administered to students at the start of year 7 students typically between 10 and 11 years of age.
Comprehensive School	A type of secondary school that does not select its intake on the basis of academic achievement or aptitude.
Effort Regulation	The management of effort in learning activities in the face of difficulties.
GCSE Results	Students' results in a national examination in England, which is administered at around age 16.
Grit	Perseverance and passion towards very long-term goals. Grit is a higher order construct, with two lower-order dimensions: *perseverance of effort* and *consistency of interest*.
Key Stage 2 (KS2) Attainment Results	National Curriculum levels achieved in tests completed at the end of year 6 (the final year of primary education in England) by students typically between 10 and 11 years of age.
Mindset about Intelligence	Individuals broadly see intellectual ability as either a fixed (fixed mindset) or malleable (growth mindset) capacity. Individuals' implicit theories about their intelligence affect their beliefs and actions.
Perceived Instrumentality	The extent to which learners perceive performing in the current task as instrumental to achieving personally valued future goals.
Self-control	The ability to regulate behaviour, thought, emotion and attention in the service of valued goals.
Sixth Form	The final two years of secondary education in England, with students typically between 16 and 18 years of age undertaking Advanced Level or other equivalent vocational qualifications.
Wechsler Adult Intelligence Scale (WAIS)	The most commonly used measure of cognitive skills, suitable for ages 16-99.

Chapter 1: Introduction

1.1 Research Background and Rationale

Academic achievement in adolescence is a complex phenomenon, dependent on factors both intrinsic to students and in their environment (Walter, 2014). The role of academic perseverance for predicting academic achievement is widely agreed upon (Farrington et al., 2012; Gutman & Schoon, 2013; Garcia, 2014; Dweck, Walton, & Cohen, 2014; Nagaoka et al., 2014). In particular, its central role in affecting academic achievement amongst adolescence has sparked great interest from educators, policymakers and researchers in recent years (Farrington et al., 2012; Gutman & Schoon, 2013; Garcia, 2014; Dweck, Walton, & Cohen, 2014; Nagaoka et al., 2014). The research literature highlights the complexities and the potential challenges associated with conceptualising and operationalising academic perseverance (Farrington et al., 2012; Gutman & Schoon, 2013; Garcia, 2014; Dweck, Walton, & Cohen, 2014), resulting in widely differing approaches adopted by researchers (see Chapter 2, section 2.3 for an in-depth discussion). In essence, this research aims to bring clarity to the study of academic perseverance amongst adolescents, by systematically examining the contribution of the key manifestations of academic perseverance to academic achievement.

To date, most of the research literature has focused on three manifestations of academic perseverance in adolescents: behavioural engagement, grit and self-control (for a review see: Gutman & Schoon, 2013). Researchers appear to use behavioural engagement merely to operationalise (rather than conceptualise) academic perseverance (see section 2.3.2 for in depth discussion), using a range of student behaviours such as attendance and homework completion to task persistence (Farrington et al., 2013; Gutman & Schoon, 2013; Fredricks, Blumenfeld, & Paris, 2004). Grit is defined as: perseverance and passion for long-term goals (Duckworth, Peterson, Matthews, & Kelly, 2007), and self-control as: the ability to regulate behaviour, thought, emotion and attention in the service of valued goals (Tangney, Baumeister, & Boone, 2004).

Researchers also differ in their consideration of academic perseverance as a global trait. For example, grit and self-control, like Big Five conscientiousness are believed to be a global traits, stable across time and situations. However, given that the growing interest in academic perseverance is rooted in the possibility for enhancing it, this view of academic perseverance bears limited educational benefit as it implies that academic perseverance is not malleable. Moreover, these constructs are domain-general and not specific to perseverance in academic settings.

Even researchers focused on perseverance in academic pursuits face specific challenges. For instance, Dweck and colleagues (2014) use the term academic tenacity, referring to students' short-term behaviours and goals carried out in pursuit of long-term goals. However, Dweck and Colleagues (2014) fall short of putting forth a measure that captures *academic* tenacity. Instead, they suggest grit, a global trait and not specific to academic pursuits, as a possible way to operationalise academic tenacity.

In this research, ***academic perseverance*** is defined as steadfastness towards short- and long-term goals focused on academic achievement. This is the researcher's definition based on synthesis of the literature on academic perseverance and is most closely aligned with academic tenacity, whilst highlighting the importance of *steadfastness* towards goals. This definition differs from grit, self-control, conscientiousness and other global traits by emphasising the specificity of perseverance to *academic* pursuits. It differs from measures of behavioural engagement such as task persistence through its focus on goals.

Conceptualising academic perseverance in this way, is aligned with the focus on short and long-term goals, but specific to goals focused on academic achievement. Moreover, by viewing academic perseverance *not* as a global trait, this working definition offers the affordance of measuring perseverance in different academic domains (for instance in different school subjects) and therefore makes it possible to address the question of its malleability.

The 2005 report from the Program for International Student Assessment (PISA), sponsored by the Organization for Economic Cooperation and Development (OECD), identifies low perseverance as a characteristic of low-performing students. It is reported that in 20 of the 23 countries, the likelihood of a low-performing student reporting low academic perseverance was higher than the average likelihood of a student reporting low academic perseverance (Lemke et al., 2005). This report is now dated and does not address the underlying causal mechanisms for this observation, nevertheless it highlights the need for research that examines the role of academic perseverance in affecting academic achievement in school-age children. Pursuing this line of research is important, since evidence also suggests that academic perseverance in adolescence predicts life outcomes beyond school, such as social behaviours, health, well-being and career prospects (Barshay, 2019; Dweck, Walton, & Cohen, 2014; Farrington, Levenstein, & Nagaoka, 2013; Heckman, Stixrud, & Urzua, 2006; Tangney, Baumeister, & Boone, 2004; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2007; Blackwell, Trzesniewski, & Dweck, 2007).

In particular, prior research suggests that most adolescents experience a decline in their academic perseverance and achievement, with the decline typically occurring as children transition to secondary school (Dweck et al., 2014; Farrington et al., 2013; Dweck & Master, 2009; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2007; Otis, Grouzet, & Pelletier, 2005; Eccles & Wigfield, 2002). McDermott and Barik (2014) emphasise the importance of adolescence for understanding academic achievement and perseverance as "the few years before a child embarks out on his own and into the real world… and questions if school is important, thus separating the achievers from non-achievers" (p. 3). This decline is a cause for concern since an increasing number of adolescents also experience a drop in their grades, impacting educational accomplishments in the long-term (Blackwell et al., 2007; Dweck & Master, 2009; Wigfield & Eccles, 2002; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Griffin, MacKewn, Moser, & VanVuren, 2013; Wigfield et al., 2007).

The decline in academic perseverance and achievement may be attributed to the changes the students face in secondary school, such as: a larger number of subjects and teachers, the increasing demand of their secondary studies, academic competition and social pressures (Anderman & Mueller, 2010; Dweck & Master, 2009; Anderman & Midgley, 1997; Wentzel & Miele, 2009). For instance, it has been found that academic competition can result in shifting the students' focus from learning and developing skills to grades in adolescents (Maehr & Midgley, 1996; Mueller & Dweck, 1998). As a result, task persistence and academic perseverance is negatively impacted in secondary school students (Blackwell et al., 2007), further increasing the risk of academic failure for adolescents (Eccles & Roeser, 2009). The effect is greater for special education students and students struggling to meet academic standards at this age (Anderman & Mueller, 2010; Byrnes & Ruby, 2007), with far reaching implications for their future educational achievement (Wigfield & Eccles, 2002; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2007).

The decline in academic perseverance is more marked in STEM subjects and in particular in mathematics, as students progress through school (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Watt, Eccles, & Durik, 2006). This can in part be attributed to the fact that some students, parents and teachers hold the binary belief that individuals are either born with a "math brain" or not (Boaler, Dieckmann, Pérez-Núñez, Sun, & Williams, 2018, p. 1). According to Boaler (2016), many students' achievement in mathematics is impacted by their lack of academic perseverance, as mathematics is "the subject area that communicates the strongest fixed ability messages and thinking" (p. 145).

This is further reflected in the number of students who pursue studies in mathematics and other STEM subjects (Rosenzweig & Wigfield, 2016), currently falling short of the growing demand for skilled workers needed in the UK (Smith & White, 2017; Wright & Sissons, 2012; Holt, Johnson, & Harrison, 2011). In the UK, STEM fields have a strong reliance on mathematics courses taken beyond age 16, making participation in these courses important in addressing the skill gap in STEM fields (Hurst & Cordes, 2017). In order to inform future policies that encourage greater participation and perseverance in mathematics, it is important to gain a deeper understanding of adolescents' academic perseverance, specifically in mathematics.

1.2 The Gap in the Research Literature

Review of the research literature on academic perseverance highlights a number of gaps in the current understanding of this complex phenomenon. The present research aims to address these gaps by examining the underlying mechanisms and the malleability of perseverance in mathematics. Moreover, drawing on trait-level measures of perseverance has meant that researchers have not examined the question of domain-specificity of academic perseverance (Farrington et al., 2012; Credé, Tynan, & Harms, 2016). By specifically focusing on the domain of mathematics and using mathematics-specific measures of academic perseverance, the question of domain-specificity of academic perseverance is addressed in the present research.

Most research to date has been focused on examining the incremental validity of grit and self-control for predicting academic outcomes. This is despite the fact that grit and self-control are trait-level characteristics and are not specific to capturing perseverance in academic settings. Using grit and self-control, as stable traits across domains, has meant that the question of domain-specificity of academic perseverance has not been addressed by prior research (Barshay, 2019; Clark & Malecki, 2019; Credé et al., 2016; Farrington et al., 2012).

Finally, determining whether academic perseverance can be enhanced has significant implications for the direction of future research, policy and practice, yet research examining the underlying mechanisms of academic perseverance and its malleability amongst adolescents is presently lacking. The present research programme aims to address these gaps in the research.

1.3 Theoretical Framework

Drawing on the established literature (see Chapter 2), in the present research academic perseverance is conceptualised as: steadfastness towards short- and long-term goals focused on academic achievement. The phenomenon of academic perseverance in adolescence is multi-faceted and complex (Dweck et al., 2014; Farrington et al., 2012). The theoretical framework for this research (see Chapter 3) is developed by extending self-efficacy theory (Bandura, 1997) and implicit theories of intelligence (Dweck, 2000), in relation to academic perseverance in adolescents. This theoretical framework aims to capture the multiple facets of academic perseverance from effort regulation for persisting in tasks to the choice of long-term goals. This perspective makes it possible to examine the underlying mechanisms affecting academic perseverance in adolescents. More importantly, this framework supports the conception of academic perseverance as malleable and can offer insights for cultivating it in adolescents. It also has the advantage of being grounded in strong theoretical and empirical evidence that addresses and captures the complexities of academic perseverance in adolescents.

1.4 Purpose of the Research Programme

Academic perseverance plays a central role in academic achievement amongst adolescents and as such is of great interest to educators, policymakers and researchers (Farrington et al., 2012; Gutman & Schoon, 2013; Garcia, 2014; Nagaoka et al., 2014). Farrington and colleagues (2012) suggest that "increasing students' academic perseverance is appealing as a goal both for education policy and classroom practice." (p. 27). As a result, research that aims to contribute to the current understanding of academic perseverance and inform how it can be cultivated is of great value in the field of education (Dweck et al., 2014; Farrington et al., 2012; Gutman & Schoon, 2013; Nagaoka et al., 2014; Rosenzweig & Wigfield, 2016), making the present research timely and worthwhile.

1.5 Chapter Summary

The aim and objectives of this research are shaped by prior research, the gaps in the literature and the theoretical underpinnings of academic perseverance. The overarching aim of this research is to gain a deeper understanding of the complex phenomenon of academic perseverance, its underlying mechanisms and how it can be enhanced. To this end, firstly a critical review of the research literature on academic perseverance and its conceptualisation is carried out (Chapter 2). Subsequently, this review informs the theoretical framework, as well as, the development and refining of the research aims and questions (Chapter 3). The researcher's philosophical stance and its implications for research methodology are discussed in Chapter 4. Two quantitative surveys (*N* = 100 and *N* = 1448) and a randomised field experiment (*N* = 152) amongst adolescents attending schools in England are used to address the research aims. Chapters 5, 6, 7 and 8 focus on the research studies using the data from the two quantitative surveys (*N* = 100 and *N* = 1448), while Chapter 9 presents the details of the randomised field experiment (*N* = 152). In Chapter 10, the implications of the overall findings of this research and its design are addressed, in light of the research literature. Chapter 11 presents the conclusions of this dissertation and provides the opportunity to reflect on the research programme, the research process and the PhD journey.

Chapter 2: Literature Review

2.1 Introduction

In recent years, there has been a growing interest in understanding and promoting academic perseverance in adolescents amongst policymakers, educators and researchers (Steinmayr, Weidinger, & Wigfield, 2018; Muenks, Yang, & Wigfield, 2017; Muenks, Wigfield, Yang, & O'Neal, 2016; for reviews see: Credé et al., 2016; Farrington et al., 2013; Farrington et al., 2012; Gutman & Schoon, 2013; Garcia, 2014; Dweck, Walton, & Cohen, 2014; Nagaoka et al., 2014). To establish the landscape of research evidence on academic perseverance in adolescents, this chapter presents a critical review of published research literature from 1996 to date (in order to capture literature published in the 20 years prior to the start of the literature review). This review identifies the keys ways in which academic perseverance is conceptualised and measured in adolescents as: grit, self-control and behavioural engagement. In order to gain a deeper understanding of this complex phenomenon, each of these three manifestations is critically examined (sections 2.3 to 2.5). Finally, the evidence base reviewed is reflected upon and summarised to create a clear picture of the literature and the current gaps in our understanding of academic perseverance in adolescents (sections 2.6 and 2.7).

2.2 The Literature Review

This literature review focuses on academic perseverance by considering individual-level characteristics in adolescent students. The initial aim of the review was to identify and understand the evidence base in this area. The following two questions guided the review:

1. How is adolescent academic perseverance conceptualised and operationalised in the research literature?
2. What are the major conclusions arising from the research literature on academic perseverance in adolescents?

In this section, the strategies for identifying the research literature are explained. In the sections that follow, the literature identified through these search strategies is reviewed to synthesise the evidence base across a range of studies on academic perseverance in adolescent students. In particular, three key manifestations of academic perseverance: grit, self-control and behavioural engagement are examined by reflecting on the evidence from the research literature.

2.2.1 Literature Search Strategies

Two search strategies were employed to identify and include the literature in this review. First, a major psychology database, PsycINFO, and an educational database, ERIC, were searched for English language, peer-reviewed published literature between 1996 and 2016, in order to capture the research landscape over a twenty-year period. The literature needed to include at least one of the keywords: “academic” or “education” or “school”; at least one of the “perseverance” or “persistence”; at least one keyword “adolescent” or “youth” and at least one of the keywords: “learner” or “student”. After examining the terms used in other research articles and reviews, the word “characteristics” was added to the “learner” or “student” as an *or* term, to reflect learner-level factors. The initial search in December 2015 returned 1853 items. The title and abstract of the literature generated from the search terms were then examined for their relevance for inclusion in this review. Since the focus of this review was to identify individual-level characteristics, a large number of articles that addressed other factors (such as pedagogy or school-specific factors) were excluded. Second, the titles of the references of the literature already identified were screened in order to include other relevant publications in the review. This strategy was used to ensure that any seminal research prior to 1996 was not omitted. To keep up to date with the newly published research literature and include literature published after 2016, the same search terms, as well as the terms: grit, self-control and engagement, were applied to setting up alerts on Zetoc and Google Scholar. The same strategies were applied to screen articles identified through these alerts. Of the ~ 2300 publications reviewed, approximately one third were identified using alerts, with ~ 170 included in the final review. The findings from this literature review are discussed in the next sections, referring only to papers found through the research terms above.

2.3 Critical Evaluation of the Central Concepts

The central concepts and manifestations of academic perseverance in adolescence, as reflected in the research literature, are closely examined and discussed in the next sections.

2.3.1 Conceptions and Manifestations of Academic Perseverance

There is widespread agreement on the importance of academic perseverance for academic achievement (Duckworth, Peterson, Matthews, & Kelly, 2007; Dweck, Walton, & Cohen, 2014; Farrington et al., 2013; Gutman & Schoon, 2013; Heckman, 2013; Heckman, Stixrud, & Urzua, 2006). Yet, it is evident that despite the rising number of research studies addressing academic perseverance in adolescents, there is a lack of consistency in how it is conceptualised and operationalised. Multiple definitions and manifestations of academic perseverance were encountered. For instance, in their review, Gutman and Schoon (2013) broadly define academic perseverance in adolescents as commitment to mastery and task completion, describing it as “steadfastness on mastering a skill or completing a task” (p. 17). Dweck and colleagues (2014), however, focus on the timescale and goals, suggesting that academic perseverance allows students to “look beyond short-term concerns to longer-term or higher-order goals, and withstand challenges and setbacks to persevere toward these goals” (p. 4).

These differences and inconsistencies may be attributed to two major challenges encountered by researchers in studying academic perseverance in adolescents; firstly, academic perseverance is only evident by observing student behaviour, making it difficult for researchers to disentangle the students’ perseverance from academic behaviour (Farrington et al., 2012). Secondly, researchers in the field report encountering a great deal of complexity in defining and measuring academic perseverance (Nagaoka et al., 2014;

Dweck, Walton, & Cohen, 2014; Gutman & Schoon, 2013). As a result, most studies to date have used trait-level, global measures of perseverance across all domains to operationalise perseverance in academic and school settings (Nagaoka et al., 2014; Dweck, Walton, & Cohen, 2014; Gutman & Schoon, 2013).

In identifying the key ways that academic perseverance in adolescents is operationalised, this review encountered three specific manifestations of academic perseverance: grit, self-control and behavioural engagement. A number of studies defined academic perseverance as behavioural engagement, operationalised by focusing on behaviours such as task persistence, effort regulation, concentration and participation in academic tasks. For instance, in one study academic perseverance was defined as engagement in demanding activities (May & Copeland, 1998). However, most of the literature on academic perseverance in this review used grit – trait-level perseverance for very long-term goals (Duckworth, Peterson, Matthews, & Kelly, 2007) – and self-control – the ability to regulate behaviour, thought, emotion and attention in the service of valued goals (Tangney et al., 2004) – to define and measure perseverance in academic settings amongst adolescents.

These manifestations were also highlighted in a number of other reviews (Farrington et al., 2012; Gutman & Schoon, 2013; Dweck, Walton, & Cohen, 2014). More recently, it has been suggested that a degree of empirical overlap exists between grit, self-control and behavioural engagement among adolescents (Muenks, Wigfield, et al., 2016). This is likely due to the fact that all three manifestations are ultimately concerned with an individual's commitment to a task or goal.

Finally, despite the fact that educators, policymakers and researchers are invested in enhancing academic perseverance in adolescents (Farrington et al., 2012; Farrington, Levenstein, & Nagaoka, 2013; Gutman & Schoon, 2013; Garcia, 2014; Dweck, Walton, & Cohen, 2014; Nagaoka et al., 2014), the research literature on the malleability of academic perseverance remains somewhat limited. In the next section, the key manifestations of academic perseverance, grit, self-control and behavioural engagement are critically evaluated. Their malleability is further examined in light of the research literature.

2.3.2 Behavioural Engagement

As a meta-construct, engagement is made up of three distinct components: behavioural, emotional and cognitive (Fredricks et al., 2004). According to Gutman and colleagues (2013): "Engagement involves how students behave, feel, and think regarding their commitment to academic tasks, activities, or school more generally" (p. 17). Only a very small number of studies in this review were concerned with engagement, focusing more specifically on behavioural engagement as a way of operationalising academic perseverance in adolescent students. In these studies, behavioural engagement was centred on participation and included taking part in academic, social, or extracurricular activities (Fredricks et al., 2004). Behavioural engagement was measured using behaviours such as task persistence, effort expenditure, concentration and participation in academic tasks. For instance, in studies of school-age learners, behavioural engagement was measured through task persistence and effort on task (Mih & Mih, 2013). In another study, the students' self-reported classroom engagement "served as a motivational resource" for task persistence (Skinner, Pitzer, & Steele, 2016, p. 2099). In a longitudinal study of middle-school students, task persistence predicted academic achievement and the learners' own perceived ability for all grade levels (Obach, 2003).

Padilla-walker and colleagues (2013) have further demonstrated a positive association between task persistence and school engagement in adolescents. The empirical studies in this review used a variety of different measures, ranging from behavioural tasks to self- or informant-reports of learner engagement (see Fredricks, Blumenfeld, & Paris, 2004 for a review). Since behavioural engagement can be captured by focusing on different aspects of student behaviour, different studies in this review implemented diverse and at times inconsistent approaches to using behavioural engagement, ranging from student engagement behaviours such as attendance or homework completion to persistence in problem solving tasks. It can be further concluded that rather than drawing on behavioural engagement to *conceptualise* academic perseverance amongst adolescent students, researchers seem to have merely used it to *operationalise* it.

2.3.3 Grit

Despite its relatively short history, grit dominates much of the research literature on academic perseverance. This can be in part be attributed to the fact that grit claims to bring transparency to the conceptualisation and operationalisation of academic perseverance, by offering a clear definition and measurement scale (Farrington et al., 2012). Grit is defined as perseverance and passion towards very long-term goals (Duckworth, Peterson, Matthews, & Kelly, 2007), with two dimensions: *consistency of interest* and *perseverance of effort*, which are commonly measured using the Grit-S as a self-report measure of grit (see section 2.5.2 for an in-depth discussion). The consistency of *interest* items in this scale aim to measure passion and commitment to a superordinate goal, while the *perseverance of effort* items aim to measure determination, diligence and hard work to meet a particular challenge, in the face of obstacles and adversity (Duckworth & Quinn, 2009).

Grit's definition was borne out of the study of elite performers and individuals at the top of their field. Duckworth explored what they had in common, finding these individuals "dogged in their pursuits", even when faced with setbacks or obstacles (Duckworth, 2016; p. 8). Moreover, Duckworth suggests that grit is crucial to staying committed to long-term goals, as well as overcoming obstacles and not giving up at the face of adversity (Duckworth, 2016; Duckworth et al., 2007). There is a growing body of research demonstrating positive correlations between academic achievement and grit (Duckworth et al., 2007; Eskreis-Winkler, Shulman, Beal, & Duckworth, 2014; West et al., 2016). These studies show that grit predicts grades (Muenk et al., 2016), high school retention (Eskreis-Winkler et al., 2014) and ranking in the National Spelling Bee competition (Duckworth et al., 2007). It is suggested that individual differences in the stamina to pursue long-term goals (grit) account for some of the variance in academic achievement (Duckworth, Peterson, Matthews, & Kelly, 2007; Farrington et al., 2012; Dweck, Walton, & Cohen, 2014; Gutman & Schoon, 2013).

To illustrate the importance of grit for success, Duckworth and colleagues (2007) suggest that one must consider the case of two equally talented, equally conscientious children who take up learning the piano, one who sticks with the piano and one who may switch to violin after some time (in absence of a single superordinate goal to master the piano and persevere toward it). These children may be equal in their talent and ability to work hard, but differ in grit, with the grittier child likely to outperform the other in mastering the piano. According to Duckworth (2007), it is persevering toward a single superordinate goal through a hierarchy of goals that accounts for the difference in performance. In other words, grit is the pursuit of a dominant superordinate goal and its lower level goals and actions with tenacity over the long run. This proposed structure, represented in Figure 2-1, relies on the alignment of lower level goals with the superordinate goals (Duckworth & Gross, 2014).

Figure 2-1 Hierarchical goal framework (Duckworth & Gross, 2014; p. 321)

Furthermore, recent empirical studies claim that grit impacts outcomes through "cumulative effort" (Robertson-Kraft & Duckworth, 2014; p. 8; Eskreis-Winkler et al., 2016). It is suggested that by staying committed to a single superordinate goal and working harder than their peers, gritty individuals complete more hours of effortful practice (Eskreis-Winkler et al., 2016).

Grit's Predictive Validity of Academic Achievement

In recent years, grit has grown in popularity amongst policymakers, educators and the popular press, with many embracing it as a silver bullet to address a wide range of educational issues (Jachimowicz, Wihler, Bailey, & Galinsky, 2018; Steinmayr et al., 2018; Credé et al., 2016; Muenks, Wigfield, et al., 2016). To examine the utility of grit for the study of academic perseverance amongst adolescents, researchers have been focused on testing grit's incremental validity for predicting academic achievement.

For instance, Duckworth and colleagues' research examines the predictive validity of grit for success outcomes beyond measures of "talent" in challenging domains (Duckworth et al., 2007), claiming: "grit, like IQ, is of ubiquitous importance in all endeavours in which success requires months or even years of sustained effort and interest" (p.1099). Further claims are made about grittier adults making fewer career changes, reaching farther in their formal education, and achieving higher grades in university (Duckworth et al., 2007). More relevant to the current research, Duckworth puts forth grit as the key predictor of academic achievement in studies of school-age children (Duckworth et al., 2007; West et al., 2014).

Despite the theoretical basis for grit's association with academic achievement, the emerging evidence is inconsistent. A large-scale UK study asserted that grit added little to the prediction of academic achievement "beyond traditional personality factors, especially conscientiousness" (Rimfeld, Kovas, Dale, & Plomin, 2016, p. 1). A study of high school students in the US suggested that self-regulation and engagement were stronger predictors of future grades than grit, with only the *perseverance of effort* dimension predicting later grades (Muenks, Wigfield, et al., 2016). In another study of high school students, self-efficacy was found to be a stronger predictor of grades than grit or its two dimensions (Muenks, et al., 2017). More recently, a study of German adolescents found that grit added very little to prediction of grades (Steinmayr et al., 2018). Similarly, a meta-analytic synthesis of the grit literature (Credé, Tynan, & Harms, 2016), based on 584 effect sizes from 88 independent samples of 66,807 individuals, reported only moderate correlations between grit and performance (an overall correlation of 0.18).

There are further inconsistencies in the results of studies that examine grit's predictive validity of academic achievement, after controlling for prior achievement. Some researchers have found that grit predicts GPA (West et al., 2016; Chang, 2014; Duckworth et al., 2007), while findings from other studies do not support this relationship (Bazelais, Lemay, & Doleck, 2016; Wolters & Hussain, 2015). A possible explanation for these inconsistencies may be due to the fact that that these studies were focused on different domains of academic achievement. It has been speculated that perhaps grit plays a greater role in certain school subjects and is more important to achievement in some academic domains for example in mathematics than in others such as languages (see Credé et al., 2016 for a meta-analytic review; Steinmayr et al., 2018).

The Two-Factor Structure of Grit

As a higher order construct, grit has a two-factor structure: *perseverance of effort* and *consistency of interest* (Duckworth et al., 2007; Duckworth & Quinn, 2009). *Perseverance of* *effort* refers to the tendency to work hard and maintain effort when faced with setbacks and challenges. *Consistency of interest* (also referred to as *passion*; Duckworth & Gross, 2014) is the tendency to maintain interest in goals over a prolonged period of time. According to Duckworth and Quinn (2009), both factors combined together have greater predictive power than each factor separately.

The short Grit scale, Grit-S, was validated by Duckworth and Quinn (2009) and is made up of eight items, four items measuring each dimension. The scale has been translated into multiple languages and subsequently validated, mirroring the factor structure of the original scale (Fleckenstein, Schmidt, & Möller, 2014; Alan, Boneva, Ertac et al., 2015; Karaman, Vela, Aguilar, Saldana, & Montenegro, 2018; Li et al., 2018). Since the Grit-S was designed based on personality theory, it measures trait-level grit and not grit in specific domains such as academic performance or more specifically in mathematics as a school subject. This poses important ramifications for examining the malleability of grit (discussed in greater detail in section 2.5.4).

To better understand the two-factor structure of grit, it is worth examining the eight items in the scale more closely. The items 2, 4, 7 and 8 relate to *perseverance of effort* and items ***1, 3, 5*** *and* **6** relate to ***consistency of interest*** (Duckworth & Quinn, 2009).

1. ***New ideas and projects sometimes distract me from previous ones.***
2. Setbacks (delays and obstacles) don't discourage me. I bounce back from disappointments faster than most people.
3. ***I have been obsessed with a certain idea or project for a short time but later lost interest.***

4. I am a hard worker.
5. ***I often set a goal but later choose to pursue (follow) a different one.***
6. ***I have difficulty maintaining (keeping) my focus on projects that take more than a few months to complete.***
7. I finish whatever I begin.
8. I am diligent (hard working and careful).

In multiple studies of school-age children, behavioural engagement and task persistence have been found to be more strongly correlated with the *perseverance of effort* dimension (Culin, Tsukayama, & Duckworth, 2014; Muenks, Wigfield, et al., 2016; Muenks et al., 2017). It has also been found that the *perseverance of effort* dimension "has significantly stronger criterion validities than the *consistency of interest* facet and that *perseverance of effort* explains variance in academic performance after controlling for conscientiousness" (Credé, Tynan, & Harms, 2016; p. 2). Moreover, Abuhassàn and Bates (2015) found that the *perseverance of effort* dimension (and not the *consistency of interest* dimension) had incremental validity for students' self-reported accomplishments above intelligence. It is, therefore, suggested that this dimension is most closely aligned with the study of academic perseverance in adolescents (Muenks, Wigfield, et al., 2016; Credé, Tynan, & Harms, 2016). Jachimowicz and colleagues (2018) suggest that this is due to the fact that the *consistency of interest* items fail to capture an individual's passion and dedication to a single superordinate goal.

In their meta-analysis, Credé and colleagues (2016) reported that the association of the *consistency of interest* dimension with undergraduate, high school and graduate school GPA was weak, whereas this association for the *perseverance of effort* dimension was weak to moderate. Closer examination of the *consistency of interest* items also highlights that this dimension may be a better indicator of a person's endurance, rather than their passion or interest. Perhaps it is more useful to see this factor as directional consistency (Useem, 2016), rather than an indication of an individual's passion in pursuit of their goals. This view of *consistency of interest* is better aligned with the role of steadfastness in academic perseverance.

Part of the discrepancies in grit's predictive validity may arise from the fact that some studies have used individuals' overall grit score (an average of the eight items on Grit-S), while others have used the scores on the subscales as the predictors of academic achievement. It is, therefore, suggested that using the overall grit score can result in drawing erroneous conclusions about overall grit's predictive validity, when it is only the *perseverance of effort* dimension that contributes to the prediction of academic achievement (Credé et al., 2016; Muenks, Wigfield, et al., 2016; Steinmayr et al., 2018).

More importantly, critics believe that Grit-S fails to capture grit's long-term quality (Muenks, Miele, & Wigfield, 2016), since the items do not really reflect the long timescales that are claimed by Duckworth. Duckworth and Yeager (2015) acknowledge the limitations of the scale and suggest that using other behavioural measures, such as academic behaviours like school attendance, biographical information about extra-curricular activities and hobbies, alongside the grit scale may help overcome some of its shortcomings for studying academic perseverance in school-age children.

Grit and Other Constructs

As a relatively new construct, many studies have focused upon similarities and differences between grit and other personality traits and constructs (West et al., 2016; Muenks et al., 2016; Ivcevic & Brackett, 2014; Credé et al., 2016; Rimfeld, Kovas, Dale, & Plomin, 2016). Examining the theoretical foundations for the association between grit and academic achievement sheds some light on the underlying mechanisms at work. Academic achievement in school relies on behaviours such as working diligently (Dweck et al., 2014; Farrington et al., 2013; Steinmayr, Weidinger, & Wigfield, 2018). This suggests that grit as a trait is similar to personality traits such as conscientiousness in having a direct impact on academic achievement. Indeed, grit is found to be highly correlated with *Big Five Conscientiousness*, with some personality trait researchers questioning the need for yet another trait (West et al., 2016; Muenks, Wigfield, et al., 2016; Ivcevic & Brackett, 2014; Credé et al., 2016; Rimfeld, Kovas, Dale, & Plomin, 2016; Jarret, 2018; Roberts, Walton, & Viechtbauer, 2006). In its defence, Duckworth describes grit as "a member of the conscientiousness family, but one with independent predictive powers" due to its long-term quality (Kamenetz, 2016; para. 31).

Beyond Duckworth's findings, others have found that after controlling for the other *Big Five* traits, academic outcomes were predicted by *Big Five Conscientiousness* and *Emotion Regulation Ability*, but not by grit (Ivcevic & Brackett, 2014). In another large-scale study with a UK representative sample (N = 4642, 2321 twin pairs), the *Big Five* personality traits predicted about 5.5% of the variance in GCSE grades with grit adding only 0.5% to this prediction (Rimfeld, Kovas, Dale, & Plomin, 2016). Others have also shown that *Big Five conscientiousness* (not grit) was the strongest predictor of academic achievement (Dale, Sampers, Loo, & Green, 2018; Dumfart & Neubauer, 2016). These findings raise further questions about whether grit adds anything to the prediction of academic achievement beyond *Big Five Conscientiousness*, highlighting the fact that the conception of grit as a trait-level construct for the study of academic perseverance needs closer examination (Jarret, 2018).

Grit has also been compared with resilience. Resilience differs from grit in that it is the dynamic process of overcoming adversity and is developmental and adaptive, rather than a trait (Gutman & Schoon, 2013). There are also similarities between grit and other constructs such as need for achievement, persistence and follow-through, behavioural engagement, instrumentality and effort regulation (Duckworth et al., 2007; Credé et al., 2016; Muenks, Wigfield, et al., 2016; Muenks et al., 2017).

To conceptually differentiate grit from these constructs, Duckworth and colleagues (Eskreis-Winkler, Gross, & Duckworth, 2016; Duckworth & Gross, 2014; Duckworth & Quinn, 2009; Duckworth et al., 2007) assert that whilst grit may be correlated to these constructs, it differs from all in two important ways: firstly, in the perseverance to pursue one superordinate goal and secondly, in its timescale of years and even decades. Yet, as previously highlighted, the Grit-S items used to measure grit do not reflect the long-term quality, despite Duckworth's emphasis on its importance as crucial in conceptualising grit (Muenks et al., 2017; Steinmayr et al., 2018). This suggests that the claims about the differences between grit and similar constructs based on grit's time-scale may not be valid.

The Perils and Promises of Grit

Today, grit is a buzzword that represents a great deal of hope and promise for predicting academic achievement (Jarret, 2018). Duckworth describes grit as crucial for staying committed to long-term goals, vital for overcoming obstacles and not giving up in the face of adversity (Duckworth, 2016; Duckworth et al., 2007). It is not surprising then, that so many educators and policymakers are seduced by the allure of grit as an educational silver bullet, despite the limited and often inconsistent evidence supporting grit's value in educational settings (Steinmayr et al., 2018; Credé et al., 2016; Muenks, Wigfield, et al., 2016). On the one hand, grit has been promoted as *the* key to enhancing student's academic perseverance through increased course enrolment and completion, especially appealing in STEM subjects (Steinmayr et al., 2018; Credé et al., 2016; Muenks, Wigfield, et al., 2016). On the other hand, grit has been presented as the desirable ability to regulate effort on a day to day basis by working diligently (Steinmayr et al., 2018). Lack of evidence has not dampened the enthusiasm for grit, resulting in its promotion amongst educators and serious attempts have been made to apply grit in school settings (Clark & Malecki, 2019; Credé et al., 2016; Muenks et al., 2017). Recently, a number of school districts in the US have begun to use grit for the purpose of between-school accountability and to measure of teacher effectiveness. Duckworth and other researchers have strongly warned against this approach without much impact (Duckworth, 2016; Duckworth & Yeager, 2015; West, 2016).

Duckworth has drawn further criticism from other researchers through her portrayal of grit in interviews and popular writings (Credé et al., 2016). For instance in a New York Times interview she said: "Grit beats the pants off I.Q., SAT scores, physical fitness and a bazillion other measures to help us know in advance which individuals will be successful in some situations." (Brooks, 2016). In her research, Duckworth states that beyond measures of talent, grit only accounts for 4% of the variation in success outcomes. This is only one of many instances where the description in the public arena has diverged from the reality of the research evidence and may explain the growing enthusiasm for applying grit in educational settings.

Further discrepancies in grit's predictive validity reported in the research literature may be explained by three possible underlying factors:

First, the discrepancies can in part be explained by the fact that different studies were conducted in different domains, for instance in mathematics and languages, pointing to the possibility that grit's predictive validity may vary according to the domain of study (e.g. in different school subjects) and contextual factors (e.g. in different school types or cultures) (Credé et al., 2016; Steinmayr et al., 2018). This observation highlights the shortcomings of defining of grit as a global trait, stable across time and different situations (Duckworth et al., 2007), especially as it is widely accepted that contexts and situations result in variations in behaviour from the stable trait (Clark & Malecki, 2019; Cormier, Dunn, & Causgrove Dunn, 2019; Schmidt, Fleckenstein, Retelsdorf, Eskreis-Winkler, & Möller, 2017; Schunk & DiBenedetto, 2016; Mischel, 2013; Pajares, 1996).

According to Duckworth, for individuals to be gritty, they must see their goal as extremely beneficial, highly achievable and the perceived cost of goal-directed behaviour as acceptable ("The Duckworth Lab Research Statement", Duckworth, 2015). On the other hand, Duckworth and colleagues promote the importance of making students grittier to help them achieve greater academic success. This further contradicts the notion of grit as a stable trait (Duckworth, 2016; Eskreis-Winkler et al., 2016). Instead, this statement suggests that an individual's grit may vary in different domains, depending on the alignment of their goal with the domain.

Moreover, grit relies on an individual's superordinate goal and the dedication of one's effort to its pursuit over periods of months and even years (Duckworth et al., 2007; Duckworth, 2016). This view suggests that the impact of grit on goal attainment and success may vary according to the nature of an individual's goal and the domain. And yet it is worth reiterating that as highlighted by Muenks and colleagues (2017), the Grit-S items do not reflect the long-term quality that is a crucial part of conceptualising grit as a construct.

Second, some of the discrepancies reported in the research literature are due to the differences in sample characteristics. For instance, the factor loadings of grit and its two dimensions differed for university and secondary (high) school students (Muenks, Wigfield, et al., 2016). This may be due to the fact that secondary school students often cannot make extensive academic choices. For example, in England, all students are required to take mathematics up to age of 16. This means that depending on whether doing well in mathematics is a student's superordinate goal or not will affect the incremental validity of grit for predicting grades in mathematics. To put it another way, grit may not be appropriate for capturing academic perseverance in different school subjects, whereas, it may be quite suitable for predicting the grades of university students who have already opted to pursue a degree in a domain that is far more likely to be aligned with their superordinate goal. In other words, the predictive validity of grit will be greater amongst individuals in contexts where they can exercise greater choice. This may explain the higher reported incremental validity of grit for predicting retention in the military or finalists in a spelling bee competition. Moreover, Duckworth (2007) asserts that grit has great predictive power in more challenging domains where progress is arduous, and obstacles and plateaus result in many giving up along the way. Perhaps since some secondary students do not find their academic studies arduous, grit's validity for predicting grades is somewhat diminished.

Third, the discrepancies in the research findings may have arisen from the fact that some studies have used the overall grit score, whilst others have used the two dimensions of grit – *consistency of interest* and *perseverance of effort* – separately (Steinmayr et al., 2018). As previously discussed, using the composite grit score can result in drawing erroneous conclusions about its predictive validity, when it has been found that only the *perseverance of effort* dimension predicts academic achievement (Credé et al., 2016; Muenks, Wigfield, et al., 2016; Steinmayr et al., 2018). This suggests that in order to make clear assertions about the predictive validity of grit, future research needs to compare the predictive validity of its two dimensions with the overall grit score.

In summary, despite the inconsistencies in recent research studies, grit and its two dimensions are conceptually well-aligned and have high criterion validity for the study of academic perseverance in adolescents (Muenks, Wigfield, et al., 2016; Muenks et al., 2017; Steinmayr et al., 2018). The key issue highlighted by recent studies of school-age children appears to be mainly one of measurement: i.e. the inadequacy of Grit-S to operationalise this conceptualisation, especially the long-term quality and the scale's ability to capture perseverance in different academic contexts such as secondary school or in given school subjects. Therefore, before looking to apply grit in educational settings, researchers need to address the gaps and the inconsistencies in the findings of recent studies in adolescents (Muenks, Wigfield, et al., 2016; Steinmayr et al., 2018). The present research aims to address these gaps in the research literature, in order to arrive at more robust conclusions about grit in academic settings.

2.3.4 Self-control

In the literature reviewed, self-control was evident as a key manifestation of academic perseverance. In the sections that follow, self-control is critically evaluated.

Human beings live in complex social structures that require them to exercise self-control (Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). Broadly speaking, exercise of self-control comes down to the choice between deciding to act self-controlled and delay gratification for a long-term valued goal at the cost of deferring pleasure or acting on impulses and choosing immediate gratification at the cost of regret. In effect, the decision to indulge or abstain comes down to a “subjective evaluation” of gratification (Tsukayama, Duckworth, & Kim, 2012; p. 320). Self-control has also been classed as an executive function (Diamond, 2013), a process that regulates behaviour to achieve goals. It has been shown that students who persevere academically achieve academic success by monitoring and regulating their impulses and by exercising self-control (Komarraju & Nadler, 2013).

The benefits of exercising self-control have long been established, through large scale, longitudinal studies (Tangney et al., 2004; Moffitt et al., 2011; Baumeister & Tierney, 2012; Mischel, 2015). The Dunedin study (*N* = 1000) in New Zealand followed children from birth to age 32. Measures of childhood self-control predicted physical health, substance dependence, personal finances and criminal offences, when controlling for intelligence, social class and mistakes made as adolescents (Moffitt et al., 2011). In this study, siblings with lower self-control had worse academic and life outcomes, despite sharing family background.

Further, higher self-control correlates with higher grades, better mental health, higher self-esteem, less binge eating and alcohol abuse, better social skills and relationships and optimal emotional responses (Tangney et al., 2004; p.271). In a large scale, longitudinal British study (*N* = 16,780), low childhood self-control predicted adult unemployment, when controlling for gender, IQ and social class. Those with low self-control had 60% more months of unemployment (Daly, Delaney, Egan, & Baumeister, 2015). Another study has shown that self-control increases subjective well-being, emphasising no evidence of detrimental consequences of too much self-control (Wiese et al., 2018).

More relevant to the present research, several studies have demonstrated positive correlations between academic achievement and self-control (Tucker-Drob, Briley, Engelhardt, Mann, & Harden, 2016; West et al., 2016; Dumfart & Neubauer, 2016; Seider, Gilbert, Novick, & Gomez, 2013; MacCann & Roberts, 2010; Duckworth & Seligman, 2005), with self-control predicting end of year grades, hours spent doing homework and the students' attendance (Duckworth & Seligman, 2005; West et al., 2016).

It is further claimed that adolescent self-control also accounts for twice as much variation in final grades, and academic behaviours such as attendance and hours doing homework as predicted by IQ (Duckworth & Seligman, 2005). Evidence further suggests that when students employed self-monitoring strategies in order to exercise self-control, their teachers and classmates reported improved academic behaviours and perseverance (Hughes et al., 2002). These collective findings suggest that failure to exercise self-control is a major factor resulting in poor academic perseverance (Farrington et al., 2012).

Adolescent self-control is also associated with balancing social life and academic responsibilities (Kuhnle, Hofer, & Kilian, 2012). Lens and colleagues (2005) put forth a dynamic motivational model of academic achievement which acknowledges the multiple interests and academic demands that adolescent students face daily. They posit that academic achievement and perseverance do not only depend on the learner's academic motivation but also on the number and strength of the learner's competing interests and demands. This view of academic perseverance relies heavily on the role of self-control in promoting desired actions and inhibiting temptations to achieve academic goals (Ent, Baumeister, & Tice, 2015). Promoting self-control can, therefore, yield improvements in academic perseverance, resulting in improved academic achievement (Véronneau, Hiatt Racer, Fosco, & Dishion, 2014).

Social norms, values and morals and the laws within which individuals are operating impact their behaviour regulation and the exercise of self-control (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Given the complexities described, any model of self-control will, therefore, be reductionist in nature. Nevertheless, the how and why of self-controlled behaviour and its relationship to academic perseverance can be better understood by closely examining the dominant competing models of self-control.

The Competing Models of Self-control

Self-control has been depicted and referred to in a variety of ways in the research literature, such as self-discipline, self-regulation, willpower, ego strength, effortful control and inhibitory control (Duckworth & Kern, 2011, p.259). Despite the differences in the various models of self-control, all models converge in describing self-control as a "quintessential feature of self-regulatory behavior" (Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; p. 77). The following section examines the key competing models of self-control: *the discounting model of impulsiveness* (Ainslie, 1975), *the hot/cool system* *approaches to self-regulation* (Metcalfe & Mischel, 1999), *the dual influence framework* (Duckworth & Steinberg, 2015), *the strength model of self-control and ego depletion* (Baumeister, Vohs, & Tice, 2007) and *the opportunity cost model of subjective effort and task performance* (Kurzban, Duckworth, Kable, & Myers, 2013).

There are certain models of self-control that present arguably oversimplified views of academic perseverance: the *discounting model of impulsiveness* (Ainslie, 1975) presents self-control as the choice between delaying a more valued outcome over a more immediate, less valued outcome, while the *hot/cool system approaches to self-regulation* (Metcalfe & Mischel, 1999) considers self-control as part of the cool-cognitive system that guides goal-directed behaviour. Both models attribute lack of academic perseverance to the failure to delay gratification and do not consider the role of ability beliefs and self-efficacy in self-controlled behaviour. There are two alternative models that provide the most useful lenses for examining academic perseverance and effort regulation specifically in academic setting and are therefore relevant to the present research: the *dual influence framework* (Duckworth & Steinberg, 2015) and *the strength model* (Baumeister, Vohs, & Tice, 2007).

The *dual influence framework* explains that at times self-control is inhibiting an impulse such as not eating a tasty cake and at other times, it requires "strengthening a desired action" (Duckworth & Steinberg, 2015, p. 1), such as practising the piano instead of going on Facebook. In other words, to exercise self-control one must feel the conflict between short-term desires and a more valued long-term goal that is more abstract or psychologically distant (Maglio, Trope, & Liberman, 2013). This model differs from other models in that it explicitly emphasises the difference between inhibition of desires and promotion of action and is useful for explaining adolescent perseverant behaviour, since students often need to avoid distractions in order to engage in schoolwork.

The *strength model of self-control and ego depletion* continues to be the dominant model of self-control with considerable supporting evidence (including two meta-analytic studies, (Hagger & Chatzisarantis, 2016; Hagger et al., 2010). This model defines self-control as the ability to regulate behaviour, thought, emotion and attention in the service of valued goals (Tangney et al., 2004). Here, self-control is seen as "a finite resource that determines the capacity for effortful control over dominant responses and, once expended, leads to impaired self-control task performance, known as ego depletion" (Hagger et al., 2010; p. 2). Baumeister and colleagues (2007) have demonstrated ego depletion in many laboratory studies. For example, they showed that refraining from eating a cookie resulted in diminished ability to persist on problem-solving tasks. In another study, exaggerating or suppressing emotions while watching a film resulted in poorer performance on a physical stamina task (Baumeister et al., 2007). According to this model, in the same way that exertion tires a muscle, the exercise of self-control results in ego depletion i.e. short-term impairments in future tasks (Baumeister, Vohs, & Tice, 2007). It is further claimed that in the long term, self-control can be strengthened and improved through repeated exercise (Muraven, Baumeister, & Tice, 1999). For instance, it has been shown that focused efforts to control behaviour in one area, such as saving money, leads to improvements in self-control in an unrelated area such as studying (Baumeister et al., 2007). A meta-analysis of 83 different studies and 198 separate experiments showed a significant, medium-sized effect of ego depletion on self-control task performance, related to effort, perceived difficulty, negative affect, fatigue and blood glucose levels (Hagger et al., 2010). These results provide considerable support for the *strength model of self-control*. Moreover, the muscle analogy mirrors the daily experiences of academic perseverance resulting in cognitive fatigue after prolonged engagement in challenging academic tasks (Hagger et al., 2010). An alternative neurocognitive explanation for ego depletion suggests that performance drop is due to a depletion process i.e. a result of shifts in attention and motivation rather than simply due to resource depletion (Inzlicht & Schmeichel, 2012). This view does not have implications for the application of ego depletion in practical terms, but rather highlights the need for inquiry into its underlying mechanisms.

Despite the weighty evidence in support of ego depletion for explaining academic perseverance, a more recent meta-analysis of the registered replication studies of ego-depletion across multiple laboratories (k = 23, total N = 2,141) reports that the size of the ego-depletion effect in these studies was small (Hagger & Chatzisarantis, 2016). However, the authors of the meta-analysis question the fidelity of some of the replication studies and warn against the dismissal of ego depletion. They emphasise that research must now address ego depletion's underlying mechanistic processes, in order to explain the inconsistencies in the results (Hagger & Chatzisarantis, 2016). Baumeister and other researchers (Baumeister & Vohs, 2016; Cunningham & Baumeister, 2016; Engber, Thompson, & Engber, 2016) have defended the phenomenon and have highlighted some of the shortcomings of the replication studies, including statistical inferences drawn and running the experiment on the computer without the necessary "habit ingraining" prior to exercising self-control. In an attempt to further understand the inconsistencies in results, a recent study used a within-subject repeated-measures ego-depletion paradigm across 12 studies, by repeatedly alternating depletion and recovery manipulations. The depletion effect was found to be meta-analytically significant, providing further support for the phenomenon of ego depletion (Francis, Milyavskaya, Lin, & Inzlicht, 2018).

As an alternative to the *strength model*, Kurzban and colleagues (2013) put forth *the opportunity cost model of subjective effort and task performance*. The authors attribute the drops in performance to voluntary decisions based on opportunity-cost assessment, instead of resource depletion. While their model aims to explain the mechanics of effort and perseverance, it fails to take into account the situational and psychological factors that determine how different individuals represent benefits and costs (Zayas, Günaydin, & Pandey, 2013). Moreover, in the absence of a competing task, this model predicts that there will be infinite task persistence, which is unrealistic (Hagger, 2013). This model also relies on the assumption that these processes are conscious and deliberate (rather than automatic) and does not take into account the task difficulty "as a major determinant of performance" (Bonato, Zorzi, & Umiltà, 2013; p. 680), hence limiting the model's predictive validity only to situations where the task demand is unknown (Gendolla & Richter, 2013).

The recent challenges to the *strength model* have resulted in its refinements. Scrutinising it in light of these alternative viewpoints has only further demonstrated the viability of the *strength model* for explaining academic perseverance (Alquist et al., 2018; Baumeister & Vohs, 2016).

Self-control impacts the choice of valued goals in academic settings and at its core can best be conceptualised as dealing with the conflict of making mutually exclusive choices (Baumeister, 2015, p. 9). Academic perseverance, in turn, relies on a student's self-control to persist, even when faced with more tempting alternatives, obstacles or setbacks (Duckworth & Seligman, 2005; Piquero, Jennings, Farrington, & Jennings, 2010; Farrington et al., 2012). In fact, more recent studies have established the relevance of ego depletion for future planning and goal directed behaviours required from adolescents in school

(Sjåstad & Baumeister, 2018; Gordeeva et al., 2017). It can, therefore, be concluded that compared with these competing models, the *strength model of self-control* remains best suited for explaining the evidence on academic perseverance (Sjåstad & Baumeister, 2018; Gordeeva et al., 2017; Baumeister & Vohs, 2016), goal pursuit and related academic behaviours amongst adolescents (Galla & Duckworth, 2015; Galla & Wood, 2015; Galla et al., 2014).

Operationalising Self-control

The review of the literature identified four key practices for measuring self-control.

1. Executive function tasks: these are higher-level cognitive tasks, requiring goal-directed, top-down control over lower level cognitive processes, such as the STROOP task or task switching paradigms (Duckworth & Kern, 2011).
2. Delay of gratification tasks: Mischel's Marshmallow Test is the most famous example of this type of task. Experimenters presented pre-schoolers with a marshmallow and told them that if they waited till the experimenter returned to the room that they would receive a second marshmallow. These tasks may include hypothetical choices (Mischel, 2015; Tsukayama et al., 2012; Duckworth & Seligman, 2005).
3. & 4. Self- and informant-report questionnaires: these have been used extensively in research due to the relative ease of administration (Gutman & Schoon, 2013).

A meta-analysis of 102 studies on self-control concluded that out of all the possible instruments, the Brief Self-control Scale (Tangney et al., 2004), was the only scale that "allowed for a fine-grained analysis of conceptual moderators of the self-control behaviour"

(Ridder et al., 2012; p.76). In short, self-control as measured by this scale related to both engaging in "desired behaviours" and inhibiting "undesired behaviours" to varying degrees. Moreover, this is the scale used to capture self-control as conceptualised by the *strength model of self-control*.

Another analysis of the convergent validity of self-control measures further suggests that using multiple methods to measure self-control can help capture the multiple dimensions of the construct (Duckworth & Kern, 2011). For instance, Galla and colleagues (2014) claim to have developed a behavioural task that captures self-control and grit in school-age learners called the Academic Diligence Task. In this task, learners face the choice of doing simple arithmetic or watching videos or playing games. The task aims to capture their productivity and engagement. By choosing to use behavioural measures alongside self-reports in this research, it is hoped to improve the ecologically validity of the measures (Duckworth & Yeager, 2015; Galla et al., 2014; Jackson, 2012) in order to offer more relevant insights to self-controlled behaviour in real-life settings.

Gaps in Self-control Research

In reviewing the current literature, two key gaps emerged which will be addressed by the present research. The first is the question of whether self-control is a trait-level construct or whether it is specific to a given domain (i.e. school or a specific subject). The second is that research addressing the underlying mechanisms of self-control is presently lacking (Baumeister & Vohs, 2016; Hagger & Chatzisarantis, 2016; Inzlicht & Schmeichel, 2012), despite the fact that development of self-control is seen as "a central concern for schools" (Wiese et al., 2018, p. 380; Diamond & Lee, 2011; Duckworth & Kern, 2011). These gaps in the research are discussed in greater detail in the following paragraphs.

Despite the growing interest in explaining perseverance in different academic domains, empirical studies that focus on domain-specificity of self-control are rare (Tsukayama et al., 2012). There is strong evidence from laboratory studies supporting the view of self-control as a trait or disposition. High trait self-control predicts better outcomes (Ridder et al., 2012) and is further linked to avoiding instead of resisting temptation (Mischel, 2013). For example, people with higher self-control are more likely to choose to work in an environment free from distractions, compared to those with lower self-control. In other words, by adopting positive habits and removing distractions from their environment, these individuals avoid motivational conflicts and preserve their ego from depletion (Mischel, 2013). A series of studies exploring the link between self-control and life outcomes suggests that positive habits play a greater role in achieving positive outcomes than "effortful inhibition" (Galla & Duckworth, 2015; p. 1). In academic settings, it has been found that adolescents with higher trait-level self-control report fewer stressors in their daily life (Galla & Wood, 2015; p.69).

Moreover, some individuals are, reportedly, more self-controlled than others, when considering self-control as a trait (Tsukayama et al., 2012). Viewing self-control as a finite resource, it can be assumed that these individuals have more self-control resource to draw on and are also better able to exercise cognitive strategies that reduce the cost of resisting temptations. Yet, it is easy to find examples that contradict this notion. An individual may be extremely self-controlled in an of aspect of her life and yet feel frustrated with herself for failing to exercise discipline in another. This points to the within-individual variance in self-control. Unsurprisingly, it has been demonstrated that attraction to one class of temptation does not suggest attraction to other classes (Tsukayama et al., 2012). Drawing on this evidence, one can hypothesise that self-controlled behaviour varies according to the domain in which it is required. In fact, it has been shown that the variability in self-control within individuals in different domains is far greater than variability between individuals (Tsukayama et al., 2012). It is believed that the variation in individuals' behaviour in different domains can be explained by their subjective evaluations of the situation. Others argue that perseverance can be the result of trait-level self-control, as well as the processes involved in strategy use to regulate effort. These findings support a more comprehensive approach to explaining success and failure and the students' attempts to persist (Hennecke, Czikmantori, & Brandstätter, 2018).

There is substantial evidence confirming that self-control varies across situations and time from "two large-scale investigations of a spectrum of behaviors", ranging from academic and health-related behaviours to personal relationships (Tangney et al., 2004, p. 271). Further, it has been shown that previous experience in a given situation, (Muraven & Baumeister, 2000; Muraven, Tice, & Baumeister, 1998), mood (Fishbach & Labroo, 2007), working memory capacity (Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008; Schmeichel, 2007), and motivation (Muraven, Rosman, & Gagné, 2007; Muraven & Slessareva, 2003) impact situational self-control.

There is an ongoing debate about what exerts the greater influence on behaviour, the situation or the domain-general trait of self-control (Tsukayama et al., 2012). Mischel (2013) concludes, "Although behaviour patterns often may be stable, usually are not highly generalized across situations" (p. 282). Mischel and Shoda (1995) hold the view that trait self-control questionnaires (that require the participant to respond to items such as 'I am self-disciplined' without any context) implicitly treat domain-specific variations as noise (Tsukayama et al., 2012).

However, viewing self-control as a trait rather than specific to a domain does impact the approach to the study of academic perseverance in adolescents. For instance, most studies to date look at trait-level self-control's incremental validity for predicting GPA (i.e. performance across all academic subjects), rather than taking the more granular approach of attempting to explain differences in a student's performance in different school subjects (Hagger et al., 2010; Baumeister et al., 2007; Tangney et al., 2004). The research to date on self-control in specific domains has been limited to examining fairly broad categories such as work, food and exercise (Galla & Duckworth, 2015). Yet, it is still likely that there is a great deal of variance within each of these rather broad categories. For instance, the extent of variance in self-controlled behaviour is likely to be lower, if we focus on mathematics as a domain, rather than overall academic performance.

In summary, evidence suggests that the variance in self-controlled behaviour within individuals is far greater than the domain-general variance across individuals (Tsukayama et al., 2012). Furthermore, it has been reported that individuals' impulsive actions are affected more by the nature of temptations in the specific domain (Mischel, 2013; Tsukayama et al., 2012). This suggests that domain-specific conceptions and operationalisations of self-control are likely to be more meaningful for studying academic perseverance in adolescents. Finally, the underlying mechanisms of self-control are likely to differ depending on the specific domain (Mischel, 2013). In the next chapter, possible underlying processes that may explain the variance in self-control in different domains will be explored in light of self-efficacy theory (for more in-depth discussion see Chapter 3).

2.3.5 Distinguishing between Grit and Self-control

It is suggested that achievement of a long-term goal requires perseverance and sustained self-control in service of a superordinate goal (Eskreis-Winkler et al., 2014). Through a number of empirical studies, Duckworth and colleagues (2007, 2009, 2014, 2015) draw clear distinctions between grit and self-control, whilst acknowledging their relatedness. They propose that to be gritty, an individual needs to exercise self-control with a long-term goal in mind. It has been shown empirically that gritty individuals, including adolescents, are more self-controlled on average (Eskreis-Winkler et al., 2014; West et al., 2016; Galla & Duckworth, 2015). Yet, it is possible for an individual to be extremely self-controlled, without "consistently" pursuing a superordinate goal (Eskreis-Winkler et al., 2014, p.319). Furthermore, many gritty high-achievers give into temptations, only to face consequences (Baumeister & Tierney, 2012).

Individuals draw on self-control to decide between conflicting actions, one that is aligned with an "enduringly valued goal" (Duckworth & Gross, 2014; p. 321) versus another stronger goal (or temptation) in that moment. The effect is either to suppress the momentary goal or to strengthen the valued goal. In effect, self-control can be seen as the "successful resolution" of a motivational conflict. The alternative to self-control is to succumb to temptation only to regret it, such as eating the cake, instead of sticking with one's diet.

On the other hand, grit is the pursuit of a dominant superordinate goal and its lower level goals and actions with tenacity over the long run. Whereas, self-control is the adherence to a goal over relatively less valued goals (Eskreis-Winkler et al., 2016). According to Duckworth (2007), the individuals' interests and passion determine their chosen superordinate goal and their ability to suppress other superordinate goals. The alternative to grit is giving up on a superordinate goal, when the going gets tough.

For self-controlled individuals, lower level goals and actions are not united to achieve a single goal and the greatest risk to self-control is temptation. Figure 2-2 illustrates the proposition that for gritty individuals the greatest risk is from alternative goals (part **a** of Figure 2-2) and obstacles (part **b** of Figure 2-2; Duckworth & Gross, 2014; p.322). According to Duckworth and Gross (2014), self-control impacts a learner's daily choices (such as completing homework before going on Facebook), whereas grit impacts more exceptional achievements that are a result of years of dedication and perseverance (such as getting into a good university).

Figure 2-2 Schematics illustrating processes underlying grit (Duckworth & Gross, 2014; p. 322)

It is, therefore, posited that grit differs from self-control in its mechanisms of operation and most obviously in timescale (Duckworth & Gross, 2014). In short, grit and self-control are related, capturing different aspects of perseverance, yet both require aligning actions with goals.

2.4 Malleability of Academic Perseverance in Adolescents

Little research to date has directly addressed the question of malleability of academic perseverance, despite many studies placing a great deal of importance on this question in educational settings. In the following section, the three key manifestations of academic perseverance: grit, self-control, and behavioural engagement (as determined by the literature review) are examined in relation to their malleability.

In the literature, behavioural engagement is conceptualised, not as a trait but rather as a student's participation in academic settings (Gutman & Schoon, 2013). This view suggests that behavioural engagement is likely to be malleable. On the other hand, grit and self-control, the two dominant manifestations of academic perseverance, are described as trait-level constructs, stable across time and different situations and therefore, less malleable (Duckworth et al., 2007; Farrington et al., 2012). This view is somewhat problematic, as while it is believed that some students may be more gritty or self-controlled than others, it is also widely agreed that their context will greatly impact their ability to persevere (Dweck et al., 2014; Farrington et al., 2012; Mischel, 2013). Contexts and situations are known to result in variations in behaviour from the stable trait (Mischel, 2013), supporting the view that as a *behaviour*, academic perseverance is malleable (Nagaoka et al., 2014). For instance, academic contexts, including but not limited to the teacher, curriculum, instructional practices, materials and resources, classroom policies and grading practices, influence student perseverance (for reviews see: Gutman & Schoon, 2013; Dweck et al., 2014; Farrington et al., 2012). A student who perseveres in one setting in a given task may give up in a different setting in a different academic task. There is great potential in pursuing this line of research, especially since an empirical study has demonstrated that the variance in gritty or self-controlled behaviour within individuals in different domains is far greater than the domain-general variance across individuals (Tsukayama, et al., 2010). Moreover, compelling results from brief social-psychological interventions further suggest that the mechanisms that enable adolescents to act more perseverant may be successfully targeted (Farrington et al., 2012; Dweck, Walton, & Cohen, 2014; Yeager & Walton, 2011; Lazowski & Hulleman, 2016). For instance, it has been found that the effects of ego depletion are eliminated when participants are urged to believe that they have unlimited self-control resource (Job, Walton, Bernecker, & Dweck, 2013). A recent meta-analysis of early self-control interventions (up to age 10) further demonstrates that these interventions are by and large effective in increasing self-control, with effect sizes ranging from 0.28 to 0.61 (Piquero et al., 2010). Similarly, while less experimental evidence exists on the malleability of grit, in a recent longitudinal randomised study with 5th and 6th grade low-achievers in mathematics, a social-psychological intervention was successfully used to increase perseverance in students even when faced with challenges and obstacles (Eskreis-Winkler et al., 2016). In fact, the underlying assumptions in the growing number of recommendations to increase grit through school-based interventions are that grit is malleable, specific to context and not a stable trait (Kirchgasler, 2018; Duckworth, 2016; Nagaoka et al., 2014; Shechtman, DeBarger, Dornsife, Rosier, & Yarnall, 2013; Farrington et al., 2012). Therefore, by moving away from viewing academic perseverance as a stable trait, there is evidence, be it limited, suggesting that it is possible to change an individual's ability to act perseverant in academic settings (Dweck et al., 2014; Farrington et al., 2012; Roberts & DelVecchio, 2000; Costa Jr & McCrae, 1994). By taking this view in my research, it is hoped that the question of malleability of academic perseverance can be addressed through an intervention study, especially since it holds a great deal of promise for educators and policymakers alike.

2.5 Gaps in the Research and Unanswered Questions

Critically reviewing the literature has highlighted three key questions that remain unanswered by current research.

1. To what extent, does the conceptualisation of perseverance as grit with the two dimensions of *consistency of interest* and *perseverance of effort* capture the phenomenon of academic perseverance in adolescents?
2. How do grit and self-control, as trait-level measures, compare with domain-specific measures of academic perseverance?

And perhaps most importantly,

3. Can academic perseverance in adolescence be enhanced?

Examining and answering these questions not only has the potential to inform the decision-making processes undertaken by educators and policymakers but is also of great importance in deepening the current understanding of academic perseverance in adolescents. These questions also inform the aims, objectives and the research questions of the present research (see section 3.5.1).

Moreover, only a small number of the studies in the current review attempted to address the underlying mechanisms of academic perseverance. In the next chapter, a more in-depth analysis of the core underlying processes is undertaken. Following this line of research can further inform future efforts to cultivate academic perseverance in adolescents, making this research very timely.

2.6 Conclusions

Academic perseverance plays a central role in academic achievement amongst adolescents and as such is of great interest to educators, policymakers and researchers (Farrington et al., 2012; Gutman & Schoon, 2013; Garcia, 2014; Nagaoka et al., 2014). In this critical review of the literature, three manifestations of academic perseverance were identified: behavioural engagement, grit and self-control. Much of the literature reviewed was focused on grit and self-control, primarily aimed at examining their incremental validity as predictors of academic achievement in adolescents. Both constructs draw upon the students' valued goals to explain academic perseverance, behaviours and achievement (Duckworth et al., 2007).

In addition, viewing grit and self-control as stable traits across domains had impacted the direction of the research carried out to date and meant that researchers had not examined the question of domain-specificity of academic perseverance (Farrington et al., 2012; Credé et al., 2016). To address this gap, the incremental validity of grit and self-control for predicting overall academic achievement and achievement in a challenging domain is considered in the present research. Moreover, comparing grit and self-control to domain-specific measures of academic perseverance can help unpack the question of domain-specificity of academic perseverance. Finally, the question of whether interventions targeting predictors of academic perseverance can enhance academic perseverance in specific domains and contexts remains to be investigated. This research aims to address these gaps in the research.

Chapter 3: The Core Underlying Mechanisms for Academic Perseverance in Adolescents

3.1 Introduction

The goal of this chapter is to identify the core underlying mechanisms and draw on them to develop a theoretical framework for cultivating academic perseverance. Examining these mechanisms in adolescents is critical to deepening the understanding of this complex phenomenon (Farrington et al., 2012; Gutman & Schoon, 2013; Dweck, Walton, & Cohen, 2014; Yeager & Walton, 2011; Nagaoka et al., 2014). According to Farrington and colleagues (2012), this is imperative since: "the evidence is strong that context-specific interventions that increase academic perseverance can have clear payoffs in terms of improved academic performance within the targeted context" (p.26).

Only a small number of studies found through the literature search (reported in Chapter 2) attempt to address the underlying mechanisms of academic perseverance, highlighting learner self-efficacy beliefs and mindsets about intelligence as the two core processes. Learners' self-efficacy beliefs are found to predict academic perseverance (Muenks et al., 2017; Muenks, Wigfield, et al., 2016; West et al., 2016). Academic self-efficacy refers to learners' conviction to perform academic tasks at designated levels or to attain a specific academic goal (Bandura, 1997; Eccles & Wigfield, 2002). It is reported that highly efficacious learners are motivated to learn and achieve mastery when faced with challenging tasks, persevering toward their goals even in the face of failure or setbacks (Pajares & Schunk, 2001). Furthermore, these learners consistently work harder and persevere, while those with low self-efficacy often give up (Bandura, 1986). When faced with challenge, students with high self-efficacy are more likely to persevere (Bandura, 1997; Pajares & Schunk, 2001), showing greater commitment to academic goals (Bandura, 1997).

Secondly, mindsets about intelligence were identified as an underlying mechanism for academic perseverance amongst adolescents in the research literature (for reviews see: Dweck, Walton, & Cohen, 2014; Gutman & Schoon, 2013; Farrington et al., 2012). Endorsing a growth mindset means believing that intelligence can be developed; while holding a fixed mindset means believing that intelligence is static and unchangeable (Dweck, Walton, & Cohen, 2014). According to Duckworth (2016), students with a growth mindset are better equipped to dealing with obstacles and can handle difficulties with greater ease than those with a fixed mindset. This enables students with a growth mindset to persevere academically, even when faced with adversity (Krovetz, 2016).

As the core underlying mechanisms for academic perseverance, an in-depth analysis of the literature on academic self-efficacy and mindsets about intelligence is undertaken in the sections that follow. Given the limited nature of the research available on the underlying mechanisms of academic perseverance, it is a priority for future research to focus on and further explore them. In addition, developing a theoretical framework for the present research can go some way towards capturing the complexities of academic perseverance in adolescents and can be the first step for cultivating it amongst adolescents.

3.2 Self-efficacy Theory

Self-efficacy can be defined as beliefs in one's abilities for mobilising the motivation, cognitive resources and courses of action needed to meet situational demands (Wood & Bandura, 1989a) and the confidence in one's ability to commit to and undertake a course of action to accomplish a task or solve a problem (Bandura, 1997). Self-efficacy is a complex, dynamic process that changes over time with new experiences and involves adapting to changes in the environment (Gist & Mitchell, 1992).

Bandura (1986) describes self-efficacy as the perception of one's own ability to succeed in particular circumstances, and positions it as the foundational motivation construct in the social cognitive theory (Bandura, 1997). Social cognitive theory views "human behaviour as a dynamic interplay of personal, behavioural, and environmental influences", referred to as the triadic reciprocal determinism (see Fig. 3.1; Pajares & Urdan, 2006, p. 340). Self-efficacy is a critical component in these reciprocal relationships (Bandura, 1997). According to this theory, one's interpretation of the result of one's actions informs and changes the environment and personal factors (emotional, cognitive and motivational), which in turn inform and change future actions (Wood & Bandura, 1989a). Self-efficacy beliefs can affect the perceptions of prospects and obstacles and can determine future choices and the willingness to persevere to achieve goals (Bandura, 1997). According to Bandura (1977), "efficacy expectations determine how much effort people will expend and how long they will persist" (p. 194). Self-efficacy is associated positively with persistence and continued effort in challenging tasks; hence improving the likelihood of their completion (Barling & Beattie, 1983, as cited in Axtell & Parker, 2003, p. 114).

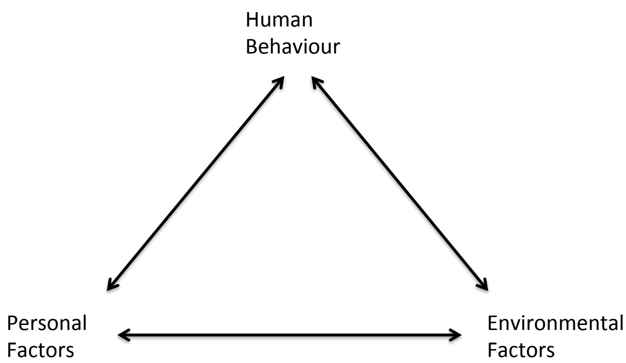

Figure 3-1 Triadic reciprocal determinism

Individuals do not simply respond to their environment, instead they actively search for and interpret information in order to form their efficacy perceptions (Bandura, 2001). Self-efficacy can be seen as being both a product of interactions in the world (enactive engagement), as well as influencing those interactions (Bandura, 1997). An individual's cognitive interpretations of successes and failures influence subsequent self-efficacy beliefs (Schunk, 1991), while at the same time, self-efficacy beliefs influence effort, persistence and the cognitive resources to interactions with the world.

Moreover, self-efficacy theory focuses on expectations by differentiating between outcome expectations, beliefs that particular behaviours will result in particular outcomes, and efficacy expectations, beliefs about whether necessary behaviours can be performed to produce the outcome (Bandura, 1997).

Figure 3-2 Self-efficacy and outcome expectations

Bandura (1997) proposes that individuals may believe that a behaviour will produce an outcome but they may not believe that they themselves can perform that behaviour (see Figure 3-2; Eccles & Wigfield, 2002). He argues ''knowing what to do is only part of the story'' (1997, p. 223), and that performance failures are frequently due to lack of confidence in how to implement skills and strategies and not due to not knowing about them (Klassen, Krawchuk, & Rajani, 2008). Therefore, self-efficacy expectations play a larger role than outcome expectations in affecting motivation and perseverance (Zimmerman, 2000). For instance, in one study, efficacy beliefs and outcome expectations together predicted 32% of all variance in reading and writing activities, with self-efficacy beliefs accounting for almost all the variance (Shell, Murphy, & Bruning, 1989).

Self-efficacy beliefs are measured along three basic scales: magnitude, generality and strength. The *magnitude* or *level* of self-efficacy refers to its dependence on task difficulty (e.g. completing increasing more challenging fractions); *generality* refers to transferability of the beliefs to other tasks (e.g. from algebra to trigonometry); and *strength* of self-efficacy refers to how certain an individual is about performing a task (Zimmerman, 2000, p. 83).

As a construct, self-efficacy has been researched in many domains and of greater relevance to this research, applied to the study of academic behaviours in school-age children (Eccles & Wigfield, 2002). There is substantial empirical evidence supporting its theoretical predictions in academic settings (Lazowski & Hulleman, 2016; for reviews see: Rosenzweig & Wigfield, 2016; Schunk & DiBenedetto, 2016). In sum, self-efficacy beliefs are important since they impact motivation, behaviour and influence the actions that can affect academic achievement (Bandura, 1997).

3.2.1 Academic Self-efficacy

Given the focus of this research on academic perseverance, it is important to examine self-efficacy in academic settings, particularly as self-efficacy is considered to be domain-specific (Pajares, 1996). Academic self-efficacy can be defined as a learner's beliefs about their ability to engage and complete the actions necessary for accomplishing a given academic task (Schunk, 1991). It has been found that academic self-efficacy can significantly affect students' success and academic outcomes in adolescents (Pajares, 1996; Pajares & Schunk, 2001; Pajares & Urdan, 2006; Schunk, 1991). For instance, it was shown that students' self-efficacy in mathematics was correlated with their end of year mathematics scores (Fast et al., 2010). Amongst undergraduate students, it was found that those with low self-efficacy had lower GPAs and were more likely to procrastinate on their academic tasks (Klassen et al., 2008). Bandura (1982) attributes high academic achievement to "high perseverance" (p.123), resulting from high self-efficacy. Moreover, academic self-efficacy influences the ability to learn, academic motivation and performance and also academic choices and goals (Lunenburg, 2011).

It has been found that learners with high self-efficacy consistently work harder and persevere, while those with low self-efficacy often give up (Bandura, 1986) and when faced with setbacks and failure, learners with high self-efficacy were more likely to persevere (Bandura, 1997; Pajares & Schunk, 2001). These findings are aligned with the working definition of academic perseverance in this research and can contribute to the current understanding of its underlying mechanisms amongst adolescence.

Self-efficacy beliefs have been found to influence key aspects of academic motivation such as level of effort, perseverance, and emotional responses (Zimmerman, 2000, p. 86). It is widely agreed that compared with other motivation constructs, self-efficacy is "by far the strongest predictor of academic achievement" (Ahn & Bong, 2019; p. 71; Bong & Skaalvik, 2003; for a meta-analysis see: Honicke & Broadbent, 2016). Acadmic self-efficacy correlates with student outcomes, including but not limited to task choice, persistence and performance, career selection, and academic aspirations (Bong & Skaalvik, 2003). In a meta-analysis of 109 studies, even after controlling for high school GPA, standardised achievement tests, and socioeconomic status, academic self-efficacy was still the strongest predictor of cumulative GPA and the second strongest predictor of academic retention (Robbins et al., 2004). It is believed that academic self-efficacy can predict and explain certain perseverant behaviours such as retention in challenging courses (Bandura, 1997). Moreover, it is reported that highly efficacious learners also show greater commitment to academic goals (Bandura, 1997) and are less likely to experience frustration and negative feelings than those with low self-efficacy (Zimmerman, 2000).

From the perspective of self-efficacy theory, students are more likely to engage and persist in activities for which they feel highly efficacious (Schunk, 2001). By worrying less about failure, highly efficacious students tend to be better prepared for challenges and are more determined to persevere in pursuit of their goals (Lent, Brown, & Gore Jr, 1997; Zimmerman, 2000). According to Pajares and Schunk (2009), "Compared with students who doubt their learning capabilities, those who feel efficacious for learning or performing a task participate more readily, work harder, persist longer when they encounter difficulties, and achieve at a higher level" (p. 2–3).

Figure 3-3 captures the different aspects of academic self-efficacy discussed here. As can be seen, personal and contextual influences interact and impact sources of self-efficacy (see section 3.2.2 for an in-depth discussion). Sources of self-efficacy affect the learner's self-efficacy expectations and outcome expectations. In turn, these expectations impact the learner's choice of academic goals such as course enrollments, academic actions such as academic task persistence and staying committed to courses instead of dropping out, and outcomes such as academic achievement (Lent, Brown, & Hackett, 1994).

Figure 3-3 A social cognitive model of self-efficacy (Lent, Ireland, Penn, Morris, & Sappington, 2017)

Figure 3-3 also demonstrates the complexities of psychological and social factors influencing achievement behaviour. Multiple studies have reported a decline in academic self-efficacy during adolescence, as students progress through school (Blackwell, Trzesniewski, & Dweck, 2007; Eccles & Wigfield, 2002; Pajares & Schunk, 2001; Schunk, Meece, & Pintrich, 2013). This can be attributed to the numerous challenges faced by the students including (but not limited to) increased academic challenge (Blackwell, Trzesniewski, & Dweck, 2007; Eccles & Wigfield, 2002; Pajares & Schunk, 2001). Academic expectations on students shift extensively with the start of adolescence. The transition to secondary school places ever increasing demands on adolescents with students needing to assume greater responsibility for their own learning (Blackwell et al., 2007; Zimmerman & Cleary, 2006; Eccles & Wigfield, 2002). For instance, in secondary school, students need to complete a great deal of school work outside school, such as doing homework and preparing for examinations. Furthermore, secondary schools promote peer competition amongst adolescents both in academic and social dimensions of their life (Wentzel & Miele, 2009) . In addition, secondary school students are required to transition between classes, maintain relationships with multiple teachers and handle differing expectations in different subject areas or the different aspects of their school life (Anderman & Mueller, 2010). It is believed that the inability to cope with these increasing demands may result in decreased academic self-efficacy and can, in turn, impact academic perseverance (Zimmerman & Cleary, 2006).

As discussed earlier, it is important to understand the underlying mechanisms for students' academic course choices, course retention and ultimately career choices (Duckworth, 2016; Nagaoka et al., 2014; Dweck et al., 2014; Farrington et al., 2012). According to self-efficacy theory, individuals' perception of their own efficacy can have a great influence on their career. It has been found that perceived self-efficacy is of greater importance than actual ability or past experience in predicting career-related choices (Hackett & Betz, 1989). In recent years, many researchers have focused on the link between perceived self-efficacy and career choice, in particular in STEM fields (Rosenzweig & Wigfield, 2016).

According to Bandura (1997), a higher self-efficacy expands the range of considered career choices and increases interest in a variety of career choices, impacting students' future course enrolments and career choices. For instance, self-efficacy in mathematics is a strong predictor of students' choice of STEM subjects as college majors and degree retention (Hackett & Betz, 1995; Hackett, 1985; Betz & Hackett, 1983). Moreover, it has been shown that adolescent students' mathematics self-efficacy influences choosing STEM-related careers (Dweck et al., 2014; Farrington et al., 2012; Dweck, 2012; Blackwell et al., 2007). It has been further suggested that targeting mathematics self-efficacy may have the potential to improve participation in STEM fields (Dweck et al., 2014; Nagaoka et al., 2014; Farrington et al., 2012; Dweck, 2012). For this reason, this research aims to target adolescents' academic self-efficacy in mathematics through an intervention study (see Chapter 9).

3.2.2 Sources of Self-efficacy

When self-efficacy beliefs are formed, individuals determine their beliefs about their ability to accomplish specific tasks based on information from four sources (Bandura, 1997; Usher & Pajares, 2008; see Figure 3-4). Mastery experiences are the most influential source of self-efficacy, providing the individual with the most authentic evidence of their competence (Bandura, 1977, 1997). If an individual has previously performed well at a task, it is more likely for them to feel efficacious and perform well at a similar task (Bandura, 1977, 1997). Success helps individuals develop robust self-efficacy in their ability, while failure and its attribution undermine an individual’s self-efficacy (Bandura, 1977, 1997). Attribution of failure will be discussed in greater detail later in this chapter.

Individuals can develop self-efficacy vicariously through observing others’ performances, by watching someone in a similar position perform and comparing themselves with the other individual’s competence (Bandura, 1977, 1997). If the individual sees someone similar to them succeed, their self-efficacy increases, while seeing someone similar fail can lower self-efficacy.

In addition, self-efficacy is developed through encouragement and discouragement related to the individual’s performance or ability to perform. The effectiveness of verbal persuasion hinges on the credibility of the person(s) providing it (Bandura, 1977, 1997). Despite the fact that verbal persuasion is likely to be a weak source of self-efficacy (compared with mastery experiences), it is widely practised as it is easy to use (Redmond, 2010).

The least influential source of self-efficacy is an individuals’ physiological state or the experience sensations from their body (such as sweaty palms or a racing heart; Bandura, 1977, 1997). For instance, if a student feels butterflies in their stomach before a mathematics test, they may assume that they are nervous which in turn may result in poor perceptions of their ability to perform in that test. This is also referred to as emotional arousal (Bandura, 1977, 1997).

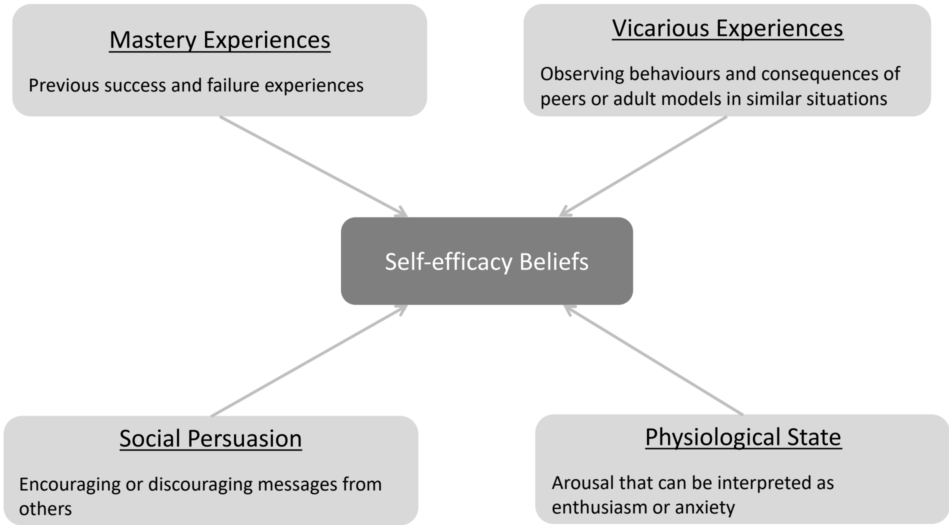

Figure 3-4 Sources of self-efficacy

The same four sources are observed for academic self-efficacy amongst school-age students. In their critical review of the literature on sources of self-efficacy in school-age children, Usher and Pajares (2008) report that mastery experiences, defined as interpretations of prior academic performance, are the most influential source of academic self-efficacy. Student self-efficacy beliefs are also formed through vicarious experiences of observing peers or significant adults such as parents or teachers. Social persuasions, in the form of feedback from others especially parents or teachers on academic performance, can also contribute to the development of academic self-efficacy beliefs. The student's physiological states such as moods, stress, anxiety and arousal in academic settings are the fourth source of academic self-efficacy belief development (Usher & Pajares, 2008). Scales such as Sources of Mathematics Self-efficacy Scale provide granular information on source of academic self-efficacy in different school subjects (Usher & Pajares, 2008).

Promisingly, Gecas (1989) proposes that academic self-efficacy can function as a self-fulfilling prophecy and can therefore be cultivated. Gecas (1989) further elaborates on the underlying processes at play and suggests that perceptions of efficacy highlight patterns of growing success or failure, stating that "Initial conceptions of self-efficacy, from whatever source, tend to become self-fulfilling prophecies, encouraging the taking of risks and giving confidence in the undertaking of new and challenging tasks. Subsequent success in these endeavors fosters an increasing sense of personal efficacy over time" (Gecas & Mortimer 1987, p. 278, as read in Gecas, 1989).

Klassen and colleagues (2008) suggest that sources of self-efficacy need to be attended to, in order to tackle procrastination and effort regulation in students. Moreover, since academic self-efficacy is related to dimensions of self-perception (Lent et al., 1997), it may be possible to enhance general academic perseverance, by targeting self-efficacy in a given academic subject. In other words, academic self-efficacy can be viewed as a resource that greatly influences whether students engage and persevere academically (Bandura, 1997).

3.2.3 Operationalising Academic Self-efficacy

At its core, operationalising self-efficacy is contingent upon the view that “the efficacy belief system is not a global trait but a differentiated set of self-beliefs linked to distinct realms of functioning” and that multi-domain measures only demonstrate the degree of generality of an individual’s self-efficacy (Bandura, 2006, p. 307). In effect, measures of self-efficacy address individuals’ capabilities in performing a task. As a result, these beliefs are domain-specific and are sensitive to context, since beliefs about performing in a mathematics test may differ greatly from beliefs about performing in a chemistry test. Pajares (1996) found that the predictive validity of self-efficacy measures improved with increased specificity. Most importantly, unlike self-concept, self-efficacy beliefs rely on a “mastery criterion of performance rather than normative or other criteria” (Zimmerman, 2000, p. 84). This means that students consider their certainty about performing a task at a given level of difficulty, rather than measuring their own performance against other students (Klassen & Usher, 2010; Pajares & Schunk, 2001). These judgments are assessed by referring to and considering future performance.

Bandura (2006) further highlights the limitations of domain-general measures, suggesting that “in an effort to serve all purposes, items in such a measure are usually cast in general terms divorced from the situational demands and circumstances” (p. 307). This view suggests that while there are multiple scales that aim to operationalise academic self-efficacy, these scales’ explanatory and predictive value would be enhanced by narrowing the domain of functioning, for example to self-efficacy in mathematics, a topic of study in mathematics and even further to a given mathematics task.

In line with Bandura’s guidelines for self-efficacy scale development (Bandura, 1997, 2006), students should be presented with items showing different levels of task demand, rating the strength of their belief in their ability to execute the required activities using a scale ranging from 0% (cannot do at all) to 100% (highly certain can do). This example illustrates the proposed approach (Bandura, 2006, p. 312):

The attached form lists different activities. In the column **Confidence**, rate how confident you are that you can do them **as of now**. Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

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

There are multiple scales used in the research literature for operationalising academic self-efficacy in adolescents that are based on Bandura's recommendations. The Academic Self-efficacy Subscale from Self-efficacy Questionnaire for Children (SEQ-C) is still the most commonly used in studies of adolescents (Muris, 2001). Participants rate general perceived academic ability on a 5-point scale (1 = not at all to 5 = very well), with a high score indicating high academic self-efficacy (see Appendix B for items). For measuring self-efficacy in a domain such as mathematics as a school subject, many different approaches have been taken. Some scales have focused on self-efficacy for solving specific mathematics problems (Betz & Hackett, 1983; Hackett & Betz, 1989). These scales contain items such as "The opposite angles of a parallelogram are ______.". The difficulty with using such scales is that the students' prior content knowledge and curriculum impact their ability to answer to the questions, making it difficult to separate subject knowledge from self-efficacy. Other scales, such as the Math Self-Efficacy subscale of the Programme for International Student Assessment (Ferla, Valcke, & Cai, 2009), also focus on efficacy for solving specific problems. This particular scale refers to rather dated concepts such as using train timetables and lacks relevance for today's students and their ability beliefs in mathematics.

In recent years, in accordance with recommendations by Bandura (2006), mathematics self-efficacy is often assessed using the average score of two items (Muenks, Wigfield, Yang, & O'Neal, 2016; Muenks, Yang, & Wigfield, 2017; for review see: Rosenzweig & Wigfield, 2016;

Credé, Tynan, & Harms, 2016). The two items, "I am confident that I can figure out even the hardest concepts in my maths lessons" and "I am confident that I can understand the material in my maths lesson" are measured on a 6-point scale from strongly disagree to strongly agree with a high score indicating high self-efficacy in mathematics.

As well as academic self-efficacy, it is evident from the research literature that mindsets about intelligence may also play a key role in the underlying processes for academic perseverance. This will be explored in detail in the sections that follow.

3.3 Mindsets about Intelligence and Academic Perseverance

There is extensive evidence demonstrating the importance of students' ability conceptions for academic perseverance (Dweck et al., 2014; Farrington et al., 2012; Gutman & Schoon, 2013; Nagaoka et al., 2014). According to Dweck (2000), individuals broadly see intellectual ability as either a fixed or a malleable capacity. Dweck (2000) suggests that individuals' implicit theories about their intelligence affect their beliefs and actions by developing "a framework that promotes judgements and reactions consistent with it" (Schunk, 1995, p. 311), differentiated by individuals' assumptions about the malleability of their intelligence (Dweck, 2000; Dweck & Leggett, 1988; Dweck et al., 2014). Individuals with a fixed view of intelligence are referred to as entity theorists and those with a malleable view of intelligence are referred to as incremental theorists. Those with incremental theories are more likely to adopt learning goals while those with entity theories are more likely to choose performance goals (Dweck & Leggett, 1988). Learning goals (also referred to as mastery goals) are focused upon improving one's own performance and gaining mastery, whereas performance goals are focused upon outperforming others and showing superior performance (Dweck, 2000; Ames, 1992; Nicholls, 1984). Most significantly, entity theorists see intelligence as unchangeable with time, whilst incremental theorists see intelligence as "synonymous with learning" (Schunk, 1995, p. 311), and a characteristic that can be developed over time with effort.

Drawing on extensive research literature, Dweck and colleagues (1988, 2000, 2014) suggest that implicit theories can impact how students react to challenges and setbacks in academic settings, their judgement of others, their reaction to social behaviours and information. Espousing an entity theory makes students more likely to give up when faced with setbacks (Zuckerman, Gagne, & Nafshi, 2001; Br\a aten & Strømsø, 2005) and more likely to view effort as an indication of lack of ability (Baird, Scott, Dearing, & Hamill, 2009). On the other hand, students with an incremental theory are more likely to pursue mastery and increase their effort (Robins & Pals, 2002).

Accepting the individual differences in the implicit theories of intelligence may help explain the differing effect of feedback amongst students (Schunk, 1995). According to Schunk (1982, 1990, 1994), when students perform poorly, if they attribute their performance to poor effort then they are likely to improve performance and will hold a better perception of their ability. On the other hand, attribution of poor performance to a lack of ability can negatively impact performance and self-efficacy (Pajares & Schunk, 2001). This suggests that giving students feedback on effort will be most effective for incremental theorists (Schunk, 1995).

With the popularisation of this theory amongst educators, these two opposing views of intellectual ability are more commonly referred to as fixed and growth mindsets. It is suggested that students who endorse a growth mindset are more likely to demonstrate academic perseverance when faced with obstacles (Krovetz, 2016), while espousing a fixed mindset results in helplessness (Dweck & Leggett, 1988; Elliott & Dweck, 1988; Elliot & Dweck, 2013; Dweck, 2000; Dweck et al., 2014). Those with a growth mindset are argued to be prepared to invest greater effort and use adaptive strategies to overcome setbacks since they see intelligence as malleable. On the other hand, those with a fixed mindset are believed to see setbacks as the limitation of their intelligence and further proof of their inability to achieve success. They view further effort required for overcoming obstacles as evidence of their own shortcomings, resulting in lowered self-efficacy, feelings of helplessness and ultimately giving up (Costa & Faria, 2018; Elliot & Dweck, 2013; Dweck & Leggett, 1988; Elliott & Dweck, 1988).

Students with a fixed mindset seem more likely to believe that learning should occur quickly or not at all, thus interpreting the need for perseverance as failure (O'Keefe, 2009). These students are likely to put in less effort; while those with a growth mindset tend to persevere and work harder (Dweck, 2000). For instance, in a study of economically disadvantaged students, mindsets about intelligence predicted perseverance when the students were faced with academic challenges (Brown, 2009). Dweck (2000) suggests that the students' mindset can in part explain some of the differences in academic perseverance and achievement.

It is widely agreed that attributing success and failure to effort and not ability has major implications for perseverance and achievement in the future (Dweck, 2012; VanderStoep & Pintrich, 2007; Bandura, 1997; Weiner, 1985). Bandura suggests that students will engage in activities "if they believe that they are competent in them" (Gregory & Kaufeldt, 2015, p. 22). This belief is really the antecedent to a student's underlying assumptions about outcomes, success and failure (Gregory & Kaufeldt, 2015). It has been shown that students who experience repeated failures, become afraid of facing challenge and are easily discouraged by setbacks (Dweck, 2012). In particular, in students with a fixed mindset, this may result in concerns about their ability as well as increased anxiety at the prospect of facing new challenges (Dweck, 2012). Exerting too much effort and still failing is considered even worse, since it strips the student of any excuses for their failure (Dweck, 2012). Therefore, these students come to see failure as a reflection of lack of intelligence, which in turn results in reducing efforts or entirely avoiding tasks and activities that may result in failure, so as to avoid providing evidence of a lack of ability (Dweck, 2012). These students are also more likely to be discouraged from seeing others struggle, fail or receive negative feedback. This, in turn, would result in putting forth less effort or not even attempting the task (Bandura, 1995). Moreover, these students come to characteristically ignore feedback and see the success of their peers as a threat (Saunders, 2013), often blaming others for their failures (Dweck, 2012).

In contrast, endorsing a growth mindset creates a love of learning, with setbacks and obstacles viewed as a natural part of the learning process (Dweck, 2000). For students with a growth mindset, their belief in the importance of effort and the processes for learning only motivates them to try harder when they fail (Blackwell et al., 2007), resulting in eventual success (Dweck, 2012). They see feedback as crucial to improvement and are keen to learn from others' success (Saunders, 2013), without assigning blame to others for their failures (Dweck, 2012). Bandura (1995) proposes that, when students with a growth mindset see others succeed academically, they believe that they too can be successful. They interpret verbal persuasion and encouragements from teachers and parents positively and may try harder at challenging tasks (Usher & Pajares, 2008).

Implicit theories are seen as characteristics of individuals and Dweck and colleagues (Dweck, 2000; Dweck & Leggett, 1988; Dweck et al., 2014) believe that, similar to dispositions, individuals have a preference for espousing entity or incremental theories of their intelligence (Schunk, 1995). Yet, it is proposed that these conceptions vary depending on tasks and contexts and in part, implicit theories of intelligence are shaped by messages about ability (Mueller & Dweck, 1998). For example, gifted students who were praised for their ability were particularly susceptible to being overly concerned with appearing intelligent and therefore avoiding challenges that threaten this identity (Yeager & Dweck, 2012). On the other hand, those who were told that their ability is malleable set challenging targets, showed better performance and maintained high self-efficacy, compared to those who received fixed ability messages, also showing a decline in their self-efficacy (Wood & Bandura, 1989b; Jourden, Bandura, & Banfield, 1991; Duda & Nicholls, 1992). It can, therefore, be suggested that students' implicit theories of intelligence are malleable and can be manipulated.

Due to the promising results of many empirical studies, growth mindset interventions are now being implemented around the world (for review see: Sisk, Burgoyne, Sun, Butler, & Macnamara, 2018). Numerous studies claim to have successfully manipulated students' mindsets about intelligence, with lasting results impacting effort regulation, deliberate practice, persistence and academic achievement (among other outcomes; Mueller & Dweck, 1998; Blackwell, Trzesniewski, & Dweck, 2007; Paunesku et al., 2015; O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014; Walton, Cohen, Cwir, & Spencer, 2012; Yeager et al., 2016). These mindset interventions work by targeting students' core beliefs about school and learning, such as "Can I learn and grow my intelligence?" (Paunesku et al., 2015, p. 2). In this way, they impact students' interpretations and responses to challenge and setbacks in school and create virtuous recursive cycles that increase greater perseverance, improving academic outcomes over time (Garcia & Cohen, 2012; Yeager & Walton, 2011). They communicate to students that intelligence can grow when students work hard on challenging tasks, reframing struggle as "an opportunity for growth" and not a sign of low ability (Paunesku et al., 2015, p. 2). These messages are consistent with self-efficacy theory in promoting mastery (Bandura, 1997; Usher & Pajares, 2008) and suggest that the effect of mindset about intelligence on academic perseverance may be mediated through self-efficacy (Dweck & Sorich, 1999; DeGeest & Brown, 2011).

More recently, several large-scale meta-analyses have evaluated mindset interventions in adolescents (Yeager et al., 2016; Paunesku et al., 2015; Baldridge, 2010; Blackwell, Trzesniewski, & Dweck, 2007). According to one meta-analytic review, mindset interventions were very effective with average effect size of 0.56 (Lazowski & Hulleman, 2016). These studies show great promise and further demonstrate the malleability of mindsets amongst school-age children. More importantly, studies are beginning to look at the impact of interventions on academic outcomes beyond grades to academic behaviours such as effort regulation. For instance, in a recent field experiment with high school students in Norway, students' mindset was experimentally manipulated. It was found that those in the experimental group put more "real-effort" into their academic performance in a mathematics task three weeks after the intervention (Bettinger, Ludvigsen, Rege, Solli, & Yeager, 2018, p. 12).

However, a recent large-scale review of mindset interventions highlights inconsistencies in the results (for the review see: Sisk, Burgoyne, Sun, Butler, & Macnamara, 2018). In this review, two meta-analyses were undertaken: the first meta-analysis (*k* = 273, *N* = 365,915) examined the relationship between mindset and academic achievement. The second meta-analysis (k = 43, N = 57,155) examined the effectiveness of these interventions for improving academic achievement. Overall effects were found to be small for both meta-analyses. Yet, it was found that students with low socioeconomic status or academically at-risk students benefited more from mindset interventions (Sisk et al., 2018).

In an attempt to understand and explain the inconsistencies in the findings from the empirical studies, Sarrasin and colleagues (2018) also undertook a meta-analysis of growth mindset interventions. They reported that developing a growth mindset by teaching students about neuroplasticity had "an overall positive effect on motivation, achievement, and brain activity" (p. 22). They also found that these interventions appear to have greater benefits for academically "at risk" students, especially in mathematics. They have attributed much of the difference in the reported results to student characteristics and subject areas (Sarrasin et al., 2018). Despite some of the inconsistencies observed, the picture for mindset interventions remains positive (Sarrasin et al., 2018), explaining the continued interest in their application to educational settings amongst policymakers and educators (Dweck et al., 2014; Farrington et al., 2012; Nagaoka et al., 2014).

3.3.1 Operationalising Mindsets about Intelligence

In most studies to date, mindsets about intelligence are operationalised using items, such as: "*You have a certain amount of intelligence and you really can't do much to change it*"; "*Your intelligence is something about you that you can't change very much*" on a 6-point scale ranging from 1 (strongly agree) to 6 (strongly disagree). The average of all items gives an overall mindset score, with those with scores of 3 or below classed as having a fixed mindset and those with scores of 4 or above with a growth mindset. However, this suggests a dichotomous view, one that represents the two mindsets about intelligence as opposites on a continuum. Dweck and colleagues (Dweck, 2012; Wentzel & Miele, 2009) argue in support of this approach, suggesting that it is justified since research participants who disagreed with fixed mindset statements defended their responses using growth mindset explanations.

However, this approach discounts the possibility that individuals can simultaneously hold both sets of beliefs, especially in academic settings (Boaler, 2016). For instance, it is possible for students to believe that there is an upper limit to their ability that cannot be surpassed through effective strategy use, effort and perseverance, at the same time as believing that this upper limit is so high that these factors can still play a significant role in improving their competence (Schunk, 1995, p. 313). Moreover, task contexts and conditions can also impact students' mindsets (Dweck et al., 2014; Farrington et al., 2012; Schunk, 1995; Nicholls, 1984). For instance, teachers' feedback on progress may encourage development of a growth mindset, whilst schools' emphasis on grades and peer comparisons may foster a fixed mindset. Moreover, students are likely to espouse different mindsets about intelligence in different domains. It is possible for a student to believe in the malleability of their ability in science and yet hold a fixed mindset in mathematics (Boaler, 2016; Blackwell et al., 2007). Research addressing the generalisation of mindsets across domains is presently limited. Drawing on more recent studies, Dweck (2012) suggests that all individuals have a mixture of fixed and growth mindsets. For instance, it is possible to have a predominant growth mindset in a domain and still be triggered by contextual factors (being really challenged or compared to others of higher ability) into a fixed mindset. It is reported that 40% of US students espouse to a growth mindset, 40% to a fixed mindset with 20% having a mixed profile (Boaler, 2016). More recently, it has been recognised that the popularisation of growth mindsets amongst teachers and students has resulted in what has been called a false mindset – the declaration of a growth mindset without truly espousing to incremental ability conceptions (Paunesku, 2015).

Recently, a series of school-based projects focused on improving academic achievement, have used four items to measure mindsets on a 5-point scale (1 = not at all true to 5 = completely true), such as: "*If I am not naturally smart in a subject, I will never do well in it*". By making the items more relevant to school and by using the 5-point scale, the authors aim to reduce the impact of the assessment instrument on viewing mindsets as dichotomous (Farrington et al., 2012; Farrington, Levenstein, & Nagaoka, 2013). It is evident that more research is required to go beyond the limitations of the dichotomous view of mindsets about intelligence. Moreover, there is still a scarcity of longitudinal research that addresses the development of mindsets about intelligence over time. This is beyond the scope of the present research and remains a gap for future research to address.

3.4 Extending the Theory: Proposing a Model of Academic Perseverance

As previously discussed, self-efficacy theory offers insights into the phenomenon of academic perseverance, as well as highlighting possible approaches for cultivating self-efficacy and in turn academic perseverance. From this perspective, the learners' choice of goals, their perseverance and achievement of those goals are related to their self-efficacy beliefs (Bandura, 1997). Higher self-efficacy is then associated with greater commitment to goals, task persistence and engagement, and greater academic perseverance (Usher & Pajares, 2008). As such, self-efficacy theory provides a useful lens for understanding and explaining academic perseverance.

Similarly, there is a great deal of evidence highlighting the importance of mindsets about intelligence for academic perseverance in adolescents (Dweck et al., 2014; Nagaoka et al., 2014; Yeager et al., 2016; Yeager & Dweck, 2012; Farrington et al., 2012; Blackwell et al., 2007; Dweck, 2000; Dweck & Leggett, 1988) . These studies demonstrate that some students choose to avoid challenges and failure when faced with setbacks, while others seek challenges and sustain efforts and strategy use under difficult conditions (Dweck, 2000; Dweck & Leggett, 1988; Dweck et al., 2014). Interestingly, what separates the two groups of students is not their ability but their mindsets about intelligence (Dweck et al., 2014; Farrington et al., 2013; Friedel, Cortina, Turner, & Midgley, 2010). In particular, the greatest difference in the behaviours of students with different mindsets relates to effort regulation and expenditure for learning new things, with those with a fixed mindset more likely to give up (Cain & Dweck, 1995) . This, in turn, has great implications for future performance, self-efficacy and perseverance in academic settings (VanderStoep & Pintrich, 2007; Dweck, 2000; Bandura, 1997; Weiner, 1985).

In fact, Dweck and Leggett (1988) suggest that implicit theories of intelligence affect self-efficacy beliefs. Students with a growth mindset about intelligence are more likely to demonstrate high academic self-efficacy (Ommundsen, Haugen, & Lund, 2005; Bell & Kozlowski, 2002). Conversely, students who espouse a fixed mindset about intelligence are more likely to have low self-efficacy (Komarraju & Nadler, 2013). Dweck and Sorich (1999) measured the students’ mindsets and academic progress over the transition from middle school to junior high. They reported that students with a growth mindset saw improvements in their mathematics grades over a two-year period. In contrast, those with a fixed mindset saw their grades deteriorate over the same period, despite similar initial mathematics achievement scores. Most significantly, this grade advantage was mediated through their self-efficacy in mathematics (Dweck & Sorich, 1999).

There is further evidence suggesting that students' mindsets affect their academic self-efficacy. Farrington and colleagues (2012) propose that for students with a fixed mindset, their mindset impacts the students' negative interpretation of academic experiences resulting in reduced effort. In order to continue to maintain being "smart", these students reduce their effort levels and fail to persevere when faced with challenging academic tasks. This, in turn, impacts their performance, further undermining their academic self-efficacy (Dweck et al., 2014; Farrington et al., 2012).

In essence, it appears that students' mindsets about intelligence can influence whether they view and interpret the relationship between effort and ability positively or as inversely correlated (Dweck, 2000), while directly impacting self-efficacy and perseverance. Moreover, it is believed that a growth mindset improves students' self-efficacy through its impact on interpretation of setbacks and failure (Dweck et al., 2014; Farrington et al., 2012; Baldridge, 2010). Thus, Dweck (2000) suggests that individuals' implicit mindsets about intelligence influence their self-efficacy beliefs. These implicit mindsets about intelligence also influence choice of academic goals (Grant & Dweck, 2003) and academic motivation (Blackwell et al., 2007). For instance, it has been found that adolescents' mathematics related mindset about intelligence positively predicts their later STEM career outcomes (Seo, Shen, & Alfaro, 2018).

Figure 3-5 shows the hypothesised model of academic perseverance, developed as part of this research based on the synthesis of the research literature. This model of academic perseverance incorporates the relationship between mindsets about intelligence and academic self-efficacy, reflecting the findings from the research literature.

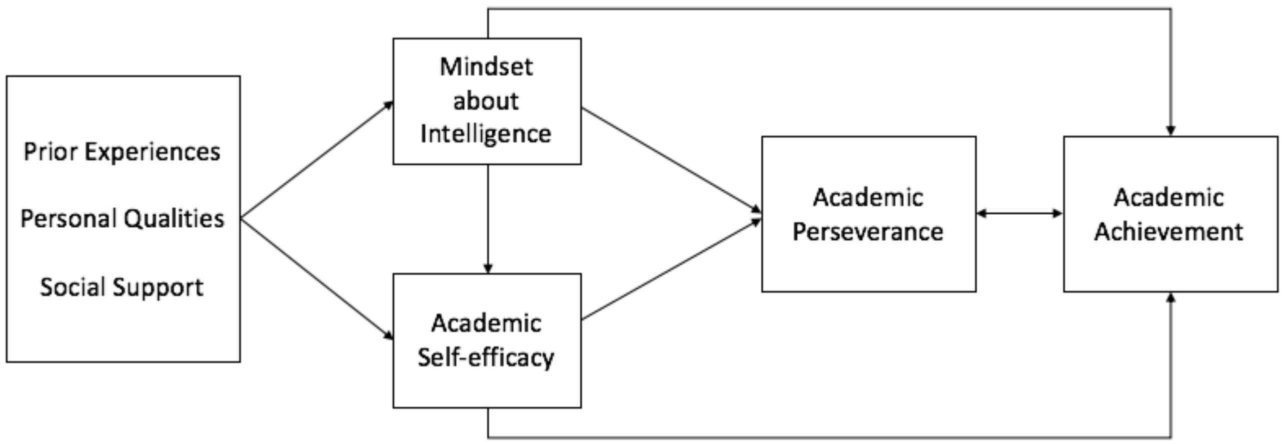

Figure 3-5 Hypothesised model of academic perseverance

By drawing on self-efficacy theory and implicit theories of intelligence (mindsets about intelligence) as the theoretical bases for explaining academic perseverance, this model aims to capture this complex phenomenon in adolescents, offering a multi-dimensional approach to understanding perseverance in academic settings. Moreover, this framework also offers the advantage of specifically incorporating psychological and social factors influencing achievement behaviour in adolescents.

3.5 Chapter Summary

This chapter provided a summary of the research literature on academic self-efficacy and mindsets about intelligence as they relate to adolescents' academic perseverance and achievement. Academic perseverance can be perceived as the culmination of students' attitudes, behaviours, choices and goals that lead to academic performance (for reviews see: Dweck, Walton, & Cohen, 2014; Nagaoka et al., 2014; Gutman & Schoon, 2013; Farrington et al., 2012). Drawing on the established literature, in this research academic perseverance is conceptualised as: steadfastness towards short- and long-term goals focused on academic achievement. Since the phenomenon of academic perseverance in adolescence is multi-faceted and complex (Dweck et al., 2014; Farrington et al., 2012), it requires a conceptual approach that captures all its facets from effort regulation for persisting in tasks to the choice of long-term goals and values. The hypothesised theoretical model (see Figure 3-5) aims to do just that.

Moreover, given the unresolved questions arising from the literature review, this conceptual framework also aims to provide a suitable lens for examining questions of domain-specificity and malleability of academic perseverance in adolescents (see section 2.5). There is ample evidence showing that academic self-efficacy and mindsets are malleable. Researchers have identified four sources of self-efficacy in adolescents (discussed in section 3.2.2; Usher & Pajares, 2008; Pajares & Schunk, 2001; Schunk, 1991; Pajares, 1996; Bandura, 1997), with a number of empirical studies showing that academic self-efficacy and perseverance can successfully be enhanced in school-age children (Schunk et al., 2013; Usher & Pajares, 2008; Pajares & Schunk, 2001; Pajares, 1996; Schunk, 1991, 1990). A large number of empirical studies also demonstrate the malleability of mindsets through brief interventions (Sarrasin et al., 2018; Sisk et al., 2018; Lazowski & Hulleman, 2016; Dweck et al., 2014). As a lens, the hypothesised model developed as part of this research is in agreement with the conception of academic perseverance as malleable and can offer insights for cultivating academic perseverance in adolescents.

As well as its multi-dimensional approach, this framework has the advantage of being grounded in strong theoretical and empirical evidence that addresses the complexities of academic perseverance in adolescents. More specifically, this model draws on self-efficacy theory and implicit theories of intelligence as the lenses to view goal commitment and persistence toward goals. This is closely aligned with the phenomenon of academic perseverance, supporting the use of this model as a theoretical framework for this research.

As discussed earlier, the students' perceptions and beliefs about of their ability and intelligence provide context for their motivation, self-efficacy, and academic success (Dweck & Master, 2009). The differences in students' academic achievement can in part be attributed to differences in their beliefs about the malleability of intelligence (Blackwell et al., 2007), but also due to their divergent self-efficacy beliefs (Pajares & Urdan, 2006; Pajares & Schunk, 2001; Bandura, 1997; Pajares, 1996). While there is ample evidence suggesting that academic self-efficacy mediates the effect of mindsets about intelligence on academic perseverance, virtually no empirical studies have yet tested this relationship. Thus, this research aims to investigate the underlying mechanisms affecting academic perseverance in adolescents by specifically examining this relationship.

3.5.1 Aims, Objectives and Research Questions

Current research, the gaps in the literature, and the theoretical underpinnings (discussed earlier in this chapter) have shaped the aim and objectives of this research. In the sections that follow, the aim, objectives and the research questions for this research are presented:

Aims and Objectives

Academic perseverance is central to academic achievement (Farrington et al., 2012; Dweck, Walton, & Cohen, 2014). Farrington and colleagues (2012) suggest that "increasing students' academic perseverance is appealing as a goal both for education policy and classroom practice." (p. 27). As a result, research that aims to inform how academic perseverance can be cultivated is of great value in the field of education (Nagaoka et al., 2014; Gutman & Schoon, 2013). Therefore, the overarching aim of this research is to gain a deeper understanding of the complex phenomenon of academic perseverance and how it can be enhanced. In addition, this research examines the question of domain-specificity of academic perseverance by using mathematics as the domain of interest. This focus on mathematics is borne out of the reported impact of perseverance on achievement in mathematics, the decline in the number of students continuing with the study of mathematics post-16 and the nature of ability beliefs held by adolescents about mathematics (Boaler et al., 2018; Boaler, 2016; Lee & Johnston-Wilder, 2017; Hurst & Cordes, 2017).

This research aim is achieved through the following objectives by:

1. Comparing the predictive validity of trait-level, school-specific and subject-specific measures of academic perseverance in adolescents for predicting academic achievement and future academic goals;
2. Drawing conclusions about the most effective ways of operationalising academic perseverance in adolescents;

3. Identifying and targeting predictors of academic perseverance through an intervention study, to determine whether academic perseverance can be enhanced in adolescents.

More specifically, the gaps in the literature are addressed by tackling the following research questions:

Research Questions

1. To what extent do the trait-level measures of grit and self-control explain the variance in academic achievement in adolescents?
2. To what extent does the conception of grit with its two dimensions capture academic perseverance in adolescents?
3. To what extent do domain-specific measures of academic perseverance exceed the incremental validity of trait-level measures for explaining the variance in academic achievement and attendance in adolescents?
4. What are the underlying mechanisms of academic perseverance in mathematics?
5. To what extent can a mastery experience intervention in mathematics promote self-efficacy in mathematics amongst adolescents?
    a. To what extent can a mastery experience intervention in mathematics promote perseverance in mathematics amongst adolescents?

Chapter 4: Methodology

4.1 Introduction

The goal of this chapter is to provide an in-depth discussion of my philosophical stance and its implications for the methodological decisions taken in this research. Moreover, I reflect on how the aims, objectives and research questions marry with my values and beliefs as a researcher in order to address the gaps in the literature. An overview of the research programme and the structure of the remaining chapters are also set out.

4.2 The Philosophical Stance

4.2.1 Examining my Values and Beliefs

Research is inextricably linked to the nature of knowledge and ways of knowing (Northcote, 2012). It is, therefore, vital to reflect and examine the influence of my values and position on my philosophical and methodological choices. This practice holds promise of deeper understanding of my research, at the same time as providing the opportunity and the means for greater reflexivity. It can also help align the purpose of my research with the ontological and epistemological choices that I have faced as a researcher.

In trying to understand my own values and my functional paradigm, I have been reflecting on my many choices over the course of my PhD research. I started my research journey believing that there was only one truth and the only way to seek that truth was through scientific inquiry. As an educator, I strongly believed that educational practice should be rooted in scientific research and was rather frustrated by policies driven by politics and based on shaky evidence. I saw objectivity as vital and held a strongly positivist stance to research.

In 2009-2010, I decided to undertake a Masters degree to help me grow both as a learner and as a teacher. And yet, while I was driven by my passion to learn from research, I was specifically looking for research that was accessible (easy to understand) and applicable to the classroom. To decide where to study, I looked at many universities and settled on the Harvard Graduate School of Education. I wanted to learn from scholars, such as David Rose, Howard Gardner and Kurt Fischer, as I admired their efforts to bridge the gap from research to the classroom by creating what they termed as "usable knowledge" and by establishing research schools (Fischer, 2009). In examining this choice, I can now see that I value research that is "usable", applicable to learning in a classroom and has the potential to change learners' lives, rather than the pursuit of knowledge for its own sake alone.

I have also become much more aware of the "nature of the relationship between the knower … and what can be known" (Lincoln, Lynham, & Guba, 2011; p. 201) and its impact on my research. My beliefs about research and how the world should be explored have certainly developed with time and impacted my own approach as a researcher. My research questions and my drive to pursue them are the result of my need to solve a real-life problem. Quite unaware of these beliefs, I have come to realise that my decision to pursue a PhD at the School of Education (rather than in Psychology) is borne out of my commitment to my overarching aim of improving learners' lives.

During the course of my PhD, I have experienced a shift in my thinking that has challenged my deep commitment to objectivity. As a researcher, I continue to believe that educational practice should be rooted in scientific research. But while I see objectivity as a cornerstone of good research, I am also aware of a possible shortcoming of scientific research in education: its applicability to the classroom context. A review of educational interventions suggests that researchers are often unable to make meaningful suggestions to educators and practitioners (Lazowski & Hulleman, 2016). There is, therefore, a tension between the objectivity of a positivist stance and the ability to find "what works best" (Teddlie & Tashakkori, 2009) in addressing the aims of my research. This has had a direct impact on my approach.

Addressing the tension between finding "what works best" and limitations of quantitative methods has significantly affected my approach to developing and answering my research questions. For instance, this has moved me to improve ecological validity of my measures by incorporating behavioural tasks alongside the surveys and instruments that I was initially planning to use, to gain a more holistic picture of my participants' lived experiences. My frustration with the limitations and applicability of correlational and cross-sectional studies to the classroom has further motivated me to pursue an intervention study with the aim of enhancing academic perseverance amongst adolescents. Examining my values, beliefs and motives has been instrumental in understanding and shaping my PhD research.

4.2.2 Pragmatism as my Philosophical Approach

"Pragmatism asks its usual question. "Grant an idea or belief to be true," it says, "what concrete difference will its being true make in anyone's actual life? How will the truth be realized? What experiences will be different from those, which would obtain if the belief were false? What, in short, is the truth's cash-value in experiential terms?"

William James (1975, p. 97)

Once my own beliefs and values were brought into focus, I began to see the affinity between my views and the pragmatic stance on many levels. Engaging with the writings of early pragmatists highlighted the alignment of my functional paradigm with pragmatism.

Peirce's work on abduction has certainly impacted my approach to research. I was thrilled to read Peirce's pragmatic maxim (1878) that to assess any statement's meaningfulness, one must consider its practical bearings.

I was and am inspired by James' notion of radical empiricism, leading "the thoughtful individual out of contemplative stagnation and toward action" (Fogarty, 2012; p. 1). As an educator, I have felt frustrated by top-down policies that were imposed on me and felt helpless for not being able to affect educational policy. James' view empowers me to use my research as a platform for change. By conducting research that has the goal of informing educators' practice (rather than result in policy change), I am in effect an empirical activist with the goal of empowering educators.

I am also inspired by Dewey's notion of cognitive and action-oriented inquiry, which led to the development of Chicago Laboratory School (Dewey, 1925; 1958). Neo-pragmatists such as Kaplan, Rorty and West have moved even further from the metaphysical by emphasising common sense and practical thinking (Crotty, 1998). Their views provide me with the means for evaluating my research, by framing my research in terms of its practical impact and contributions to the field of education.

Kuhn (1962, p. 24) suggests that pragmatism affords the researcher the freedom to break free of the restrictions of any single paradigm, and to use the research questions as the dictators of the most appropriate research methods. In looking for answers to my research questions, I am aware that a pluralistic approach, drawing on "observation, experience, and experiments" (Johnson & Onwuegbuzie, 2004, p. 20) will result in a deeper understanding of the complexities of academic perseverance in adolescents.

Pragmatism is also well aligned with my personal need for autonomy. Commitment to any given philosophical stance can impose mental and practical constraints by forcing the researcher to make ontological and epistemic choices (Creswell, Plano Clark, 2007). Pragmatism avoids the contentions of truth and reality (Peirce, 1878) and offers a view of "singular and multiple realities that are open to empirical inquiry and orients itself toward solving practical problems in the real world" (Creswell, Plano Clark, 2007, p. 27).

In examining the constraints of pragmatism, I am aware that there is a risk of incommensurability between objectivism and subjectivism. Using the *utility* of my research as my guiding principle enables me to focus on the ontological and epistemological issues arising from this stance (Crotty, 1998). Objectivity lies at the core of positivist research and the researcher is portrayed as value-free (Mertens, 2014, p.12). Despite my commitments to objectivism and quantitative research, I now believe that true objectivity is only possible if a researcher is able to engage in reflexivity and examine her own role in the research. Pragmatism allows me to use the scientific method and to acknowledge the context and the situatedness of my research (Creswell, 2003). By taking the pragmatic stance, I will be taking "an explicitly value-oriented approach to my research" (Johnson & Onwuegbuzie, 2004, p. 17).

In summary, pragmatism is well-aligned with my functional paradigm. It advocates a pluralistic, problem-centred approach for capturing the complexities of educational research (Johnson & Onwuegbuzie, 2004). It acknowledges that the relationship between the observer and their observation is interconnected and multifaceted (Jayanti, 2011). This view of knowledge production supports the use of methods that are best suited for answering the research problem in hand (Johnson & Onwuegbuzie, 2004). It is, therefore, important to examine the research aims and objectives, as well as the research questions arising from the gaps in the literature, to arrive at suitable research methods and design.

4.3 Research Methods and Design

In recent years, use of quantitative methods in educational research has been a hailed a success as a means of providing "unbiased determinations of which education practices are effective for education in general and for improving the educational achievement and opportunity of the neediest students" (Pogrow, 2017, p. 1). Moreover, it is critical to consider the proliferation of empiricism as the gold standard in educational research as the backdrop of my work (Lather, 2006). More specific to this research, empirical research drawing on quantitative method is well suited for addressing the research aims and questions, as highlighted by previous research in this field (Pogrow, 2017; Garcia, 2014; Tseng & Nutley, 2014; Gutman & Schoon, 2013). Moreover, my ontological and epistemological beliefs agree with the probabilistic (rather than deterministic) nature of my knowledge claims. Ontologically, I will seek "reality" to a given probability with the awareness of its imperfection (Mertens, 2014, p.15). This appears well aligned with the use of quantitative methods for my research.

Of course, it is important to be aware of the shortcomings of quantitative methods (Mertens, 2014; Tashakkori & Teddlie, 2010; Teddlie & Tashakkori, 2009). For instance, while surveys and inferential statistics can point to aspects of learners' beliefs and experiences, they fall short of capturing their totality. However, I am equally aware that to effect change in education and in the community of psychologists, I need to utilise quantitative methods that enable me to address each research question. This is especially important since the dominant paradigm in the psychology of education is post-positivism which relies on quantitative methods. My intention to use statistics as the primary language of discourse can be interpreted as my *pragmatic* approach in the "theatre of persuasion" (Lather, 2006, p.49) that is today's climate of educational research (Howe, 2004). In summary, my pragmatic stance empowers me to use quantitative methods "to produce socially useful knowledge" in the field of education (Feilzer, 2010, p. 6). In the sections that follow, an overview of the research program as it pertains to the aims and the research questions will be discussed.

4.3.1 The Research Programme

This research programme was designed to address the gaps in the literature, as formulated in the specific research questions (see section 3.5.1). Five studies were undertaken sequentially. The findings from each study had implications for the design of the next study. Figures 4-1, 4-2 and 4-3 broadly summarise the research programme and its timeline.

Data Collection	Data Type	Research Questions
Observational Studies: Small and Large-scale Surveys	Self-report Questionnaire & Behavioural Task Responses, Academic Attainment Results Demographic Data	1. To what extent do the trait-level measures of grit and self-control predict academic achievement in adolescents? 2. To what extent does the conception of grit with its two dimensions capture academic perseverance in adolescents? 3. To what extent do domain-specific measures of academic perseverance exceed the incremental validity of trait-level measures for predicting academic achievement and attendance? 4. What are the underlying mechanisms of academic perseverance in mathematics?
Field Experiment: A Randomised Controlled Trial	Self-report Questionnaire & Behavioural Task Responses, Academic Attainment Results Demographic Data	5. Can academic perseverance be enhanced in mathematics amongst adolescents? a. Can targeting key predictors of academic perseverance in mathematics result in increased perseverance?

Figure 4-1 Summary of the research programme

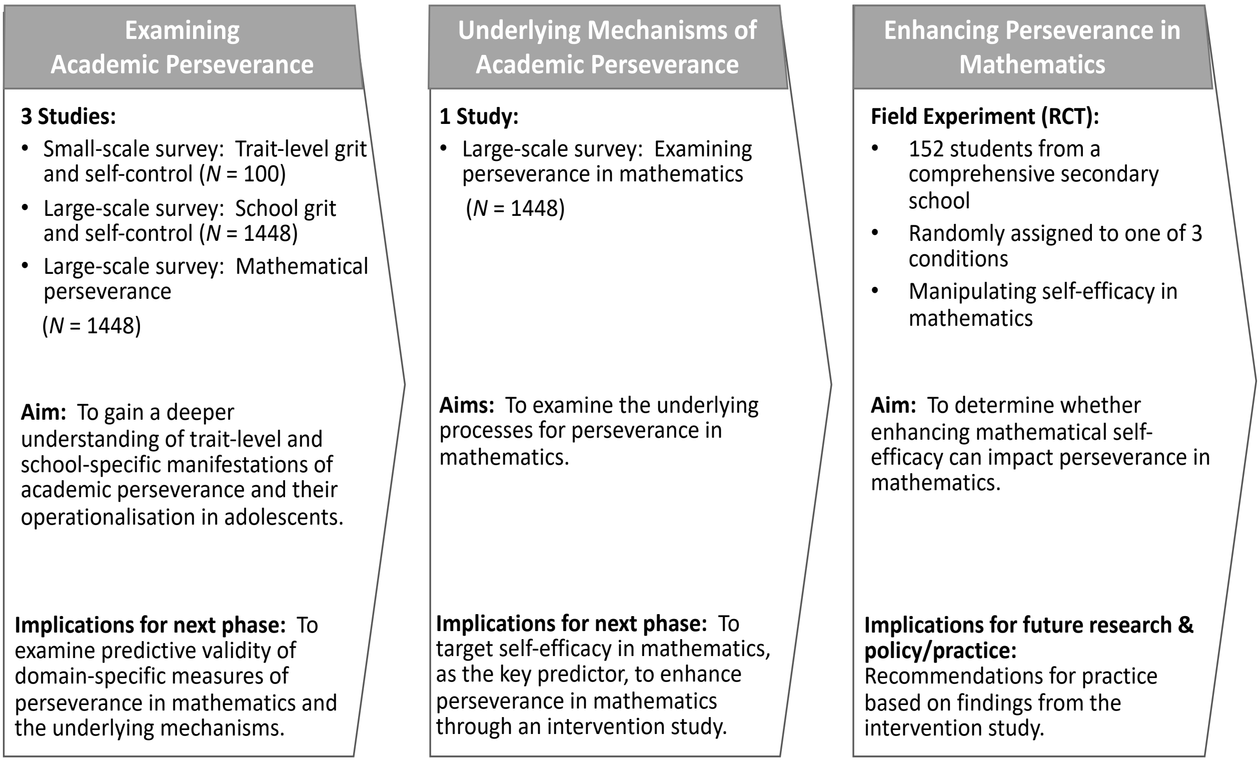

Figure 4-2 Sequential research design

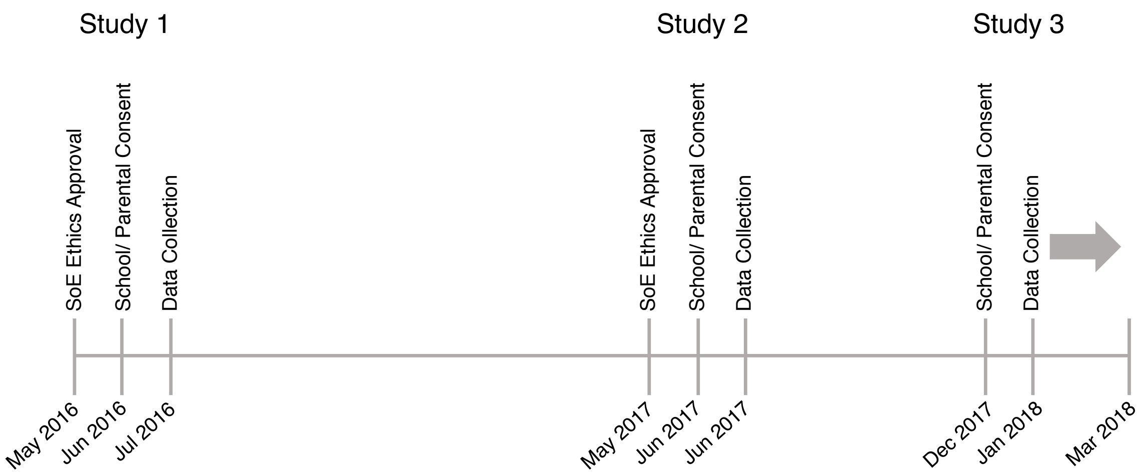

Figure 4-3 Timeline of the research programme

In this thesis, each study will be presented in a separate chapter. For each study, the research questions, hypotheses, methods and analysis will be reported. The implications of the findings for the design of the next study, future research and practice will also be discussed. Finally, a discussion chapter will bring together and synthesise the findings from all five studies.

4.4 Ethical Considerations

The overarching aim of this research is to *do good,* by contributing to the understanding of perseverance amongst adolescents in school settings. Axiologically, this is an ethical aim that is well aligned with my pragmatic approach of addressing a real-world problem. As pragmatic research is judged by its utility (Mertens, 2014), my research was situated in a school setting, to enable the transfer of findings to other schools (unlike most psychology research carried out in the lab with undergraduates due to convenience and access). Moreover, the students were likely to be more comfortable at the familiar setting of their own school. As part of the exit strategy, a presentation was made to the students and teachers in each school explaining the goals of the research and sharing some of the research findings on academic perseverance.

Research entails grappling with ethical decisions throughout every stage. Therefore, it was more helpful to see ethics as an ongoing process, rather than a finite event that required completing a form. Nevertheless, it was vital to rely on the British Psychological Society's guidelines and the University of Bristol, School of Education Research Ethics procedures to think about this research. Appendix A summarises the key ethical considerations for my School of Education Ethics Applications for each study.

Chapter 5: Exploring Academic Perseverance in Adolescents

This study focuses on examining the validity of two key manifestations of trait-level perseverance, grit and self-control, for explaining the variance in academic achievement in Sixth Form students from two comprehensive secondary schools in England.

5.1 Aims and Objectives

The overarching aim of this study was to specifically focus on the operationalisation of trait-level perseverance as grit and self-control, in order to determine their validity for explaining the variance in academic achievement amongst adolescents in England. This aim was achieved through the following objectives by:

- Inspecting the factor structure of trait-level constructs of grit and self-control for an adolescent sample in England;
- Investigating the validity of these trait-level constructs for explaining the variance in academic achievement (as measured by average GCSE points scores and GCSE mathematics grades);
- Investigating the validity of these trait-level constructs for explaining the variance in performance in a behavioural task (CountDown).

5.2 Research Questions and Hypotheses

The key research questions addressed in this study were:

RQ1: To what extent, do grit and self-control explain the variance in overall academic achievement in adolescents?

RQ2: To what extent, do grit and self-control explain the variance in achievement in mathematics (as a specific domain/ school subject) in adolescents?

RQ3: To what extent, do grit and self-control explain the variance in performance in a behavioural task?

As discussed in Chapter 3, grit and self-control are trait-level constructs and are assumed to be stable across different situations and over time (Duckworth, Peterson, Matthews, & Kelly, 2007; McAdams & Pals, 2006). However, it is known that contexts and situations result in variations in behaviour from the stable trait (Mischel, 2013). For instance, if a student's highest goals are not aligned with their academic goals and academic subjects, then grit and self-control are likely to play a limited role in their actions towards achieving these academic goals. It is, therefore, hypothesised that grit and self-control, as trait-level measures of perseverance, would make a small contribution in explaining the variance in academic achievement (as measured by average GCSE points scores or GCSE mathematics grades) in secondary school students.

5.3 Preparing for the Study

5.3.1 The Pilot Study

Prior to conducting Study 1, a small-scale pilot study was carried out with 15 students to provide the opportunity to:

- Test out the measures and the behavioural task;
- Gain a better estimate for the time needed for data collection, in order to put together a more robust timeline for future studies;

- Engage in coding and data processing and make any necessary changes to the data structure;
- Be able to anticipate possible problems arising from naïve researcher assumptions;
- Experience being in the field;
- Re-examine ethical decisions prior to embarking on the research programme;
- Plan modifications to assumptions, research questions and research design, in light of the findings.

The goal of this pilot was to engage in research on a small scale, in order to reduce the risks to the research programme. The pilot was successfully conducted and resulted in small modifications to Study 1, as detailed below:

Prior to selecting the final measures, eight scales (GRIT-S, Brief Self-control Scale and five different self-efficacy scales) were piloted with a small group of 15 students. In the pilot, three different scales measuring academic self-efficacy were used in order to identify their suitability for use with English adolescents in academic settings. As a result of the observations made during the pilot study, certain changes were made to the pen and paper survey for Study 1.

For example, some of the items from the Math Self-Efficacy subscale of the Programme for International Student Assessment (Ferla, Valcke, & Cai, 2009) confused some students since they referred to rather dated concepts such as using train timetables. Also, following Bandura's guide for constructing self-efficacy scales (Bandura, 2006), the mathematics self-efficacy scale was used (see Figure 5-1). In the pilot, despite clearly explaining the instructions, almost all students did not correctly use the scale and only ticked a single line. As a result, it was decided not to use these two scales in the final survey for Study 1.

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

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

		Confidence (0-100)
Can solve	10% of the problems	_____
"	20% " " "	_____
"	30% " " "	_____
"	40% " " "	_____
"	50% " " "	_____
"	60% " " "	_____
"	70% " " "	_____
"	80% " " "	_____
"	90% " " "	_____
"	100% " " "	_____

Figure 5-1 Mathematics self-efficacy scale based on Bandura's scale development guidelines

Instead, mathematics self-efficacy was assessed using the average score of two items written in accordance with recommendations by Bandura (2006). The details of the measures used in Study 1 will be discussed in section 5.5.3. Sources of Mathematics Self-efficacy was also used to provide more granular information on source of mathematics self-efficacy. However, this scale (which has 24 items) was the last part of the pilot self-report survey. I observed students sighing upon turning the page and seeing 24 questions. It was decided to bring this scale forward in the booklet and end with a shorter scale.

One final error that was spotted during the pilot was the question about "AS Subjects". As not all students take AS level subjects (some take GNVQs for instance), this was changed to "Year 12 Subjects" instead.

5.4 Study 1 Research Design

A cross-sectional design was used to collect the data for this study, using a survey and a behavioural task. This design was suitable for addressing the aims of this study and was a time and resource efficient way to collect the data.

5.5 Methods

5.5.1 Participants

The participants in this study were selected from two comprehensive schools in England. Table 5-1 shows the characteristics of the student population for the two schools in this study, based on 2017-18 data retrieved from https://www.compare-school-performance.service.gov.uk/.

Table 5-1 School population characteristics

School	Pupils on Roll	Pupils with SEN Support	Pupils with EAL	Pupils eligible for FSM
School 1	~1300	11%	6%	20%
School 2	~800	5%	21%	20%
England -Secondary Schools		**10.4%**	**16.5%**	**28.6%**

The sample included *N* = 100 Sixth Form students (*M* age = 17.35 years, *SD* = 0.46). There were *N* = 42 male students (*M* age = 17.42, *SD* = 0.54) and *N* = 58 female students (*M* age = 17.30, *SD* = 0.38). The reason for selecting a sample of Sixth Form students was threefold: firstly, as these students were aged 16 and above, they were better able than younger students to reflect and engage with self-report questionnaires. This eliminated the need for informant (parent or teacher) questionnaires. They also understood the informed consent form for participating in the study (Heath, Charles, Crow, & Wiles, 2007). Secondly, Sixth Form students have already narrowed their academic subjects. Their post-16 subject choices could be used as an indication of their long-term goals. Thirdly, it was possible to use GCSE exam results (as the national standard) to compare students' academic achievement.

The students were recruited though their schools, with an information letter and opt-out consent form sent home prior to the study being carried out. The students were introduced to the researcher on the first day of data collection. Those interested in taking part in the study were asked to come to the Sixth Form Common Room in each school for a brief information talk on the study, procedures for data collection, consent and the complaint procedure. All of the students who attended the information session chose to take part in the study and their written consent was also obtained following this information session. The response rate was 100% for those attending the information session. After completing the survey and the behavioural task, the students were asked to complete a cognitive ability test individually at a later date.

5.5.2 Procedure

In June 2016, after a brief introduction to the study, the students were asked to complete a booklet containing demographic information, the behavioural task CountDown, as well as self-report scales combined into a single pen and paper survey, as detailed below. This was done in groups in each school and took under one hour to complete. The students were then debriefed and details of the complaint procedure and the right to withdrawal from the study were given out. The students were also advised about the procedures for the cognitive skills assessment over the days following the group data collection.

5.5.3 Measures

Figure 5-2 demonstrates the final measures used in Study 1:

Study 1 Measures

Demographic & Background Variables

- Date of birth
- Gender
- Current school subjects
- GCSE Average Points Score
- GCSE Maths Grade (provided by the school)

Cognitive Ability Measures

- Cognitive Skills measured by Weschler Adult Intelligence Scale (WAIS)

Self-report Scales

- Grit-S
- Brief Self-control Scale
- Academic Self-efficacy (SEQ-C)
- Mathematics Self-efficacy
- Sources of Mathematics Self-efficacy
- Maths Goal

Behavioural Task

- Behavioural Engagement Task - CountDown

Figure 5-2 Measures used in Study 1

Demographics and Academic Attainment

Participants were asked to report their date of birth and gender. The students' academic achievement data were provided by the schools, after the data collection. The GCSE, a UK wide national examination which is administered at around age 16, was used as the measure of academic achievement. The students' GCSE grades for the core, compulsory subject of mathematics, as well as, the average GCSE points score (as a measure of overall academic performance) were provided. Schools were unable to provide Key Stage 2 and 3 student performance data, as measures of prior attainment and academic progress. The average GCSE points score was not available for six of the students in Study 1.

Self-report Measures

Grit

The 8-item Short Grit Scale (GRIT-S, Duckworth & Quinn, 2009) was administered to participants who rated how much they identified with the items using a 5-point scale (1 = not like me at all to 5 = very much like me). The scale consists of eight items. In this scale, four items measure students' *consistency of interest* (e.g., "I often set a goal but later choose to pursue a different one"), and four items measure students' *perseverance of effort* (e.g., "I am diligent"). A high score indicated high grit (α = .75 for the composite grit score, α = .64 for the *consistency of interest* dimension and α = .67 for the *perseverance of effort* dimension).

Self-control

The adapted 10-item Brief Self-control Scale (Tangney, Baumeister & Boone, 2004) was used to measure the individual differences in self-control in participants using a 5-point scale (1 = not like me at all to 5 = very much like me). A high score indicated high self-control (α = .83).

Academic self-efficacy

The Academic Self-efficacy Subscale from Self-efficacy Questionnaire for Children (SEQ-C, Muris, 2001) was used, with participants rating general perceived academic ability on a 5-point scale (1 = *not at all* to 5 = *very well*) . A high score indicated high academic self-efficacy (α = .78).

Mathematics Self-efficacy

Mathematics self-efficacy was assessed using the average score of two items written in accordance with recommendations by Bandura (2006; "I am confident that I can figure out even the hardest concepts in my maths lessons" and "I am confident that I can understand the material in my maths lessons") on a 6-point scale from strongly disagree to strongly agree, with a high score indicating high self-efficacy in mathematics ($\alpha = .81$). Furthermore, Sources of Self-efficacy in Mathematics was assessed using a 24-item instrument, on a 6-point scale from Strongly Disagree to Strongly Agree (Usher & Pajares, 2009).

Maths Goal

The students were asked whether they were taking mathematics beyond GCSE, as well as their intention to enrol in an apprenticeship/ a university course requiring mathematics or intention to choose career requiring mathematics after leaving school. Their responses were coded as 0 if the student had not intended to continue beyond GCSE and the number for positive responses to the questions above (1-3) was coded as their Maths Goal, as an indication of the alignment of their superordinate academic/ career goals with the study of mathematics.

The Behavioural Task

Recent research has highlighted the limitations of self-report surveys and the importance of using multiple measures for constructs such as grit and self-control (Duckworth & Yeager, 2015; Galla et al., 2014). It has been recommended to use self-reports alongside behavioural tasks and even more ecologically valid measures such as attendance and school behaviour (academic achievement, rewards, non-compliance and suspensions; Jackson, 2012).

The design and use of CountDown as the behavioural task were based on behavioural tasks used in previous research in academic perseverance, most notably the Academic Diligence Task (ADT). In this task, students are asked to complete simple mathematical calculations, but they are able to switch to games such as tetras or surf the net instead, at any time. This task has demonstrated positive associations with grit and self-control and has been promoted as an ecologically valid measure of academic perseverance. However, ADT has a major shortcoming that undermines its ecological validity: it does not reflect the students' experiences of secondary mathematics classrooms. Since the ADT was to be used with students from diverse ages and with varying mathematical backgrounds, the mathematics questions were kept very simple (e.g. 4 x 6). As a result, the task was rather mundane and was not a realistic representation of the students' problem-solving experiences in their lessons and the students were less likely to feel frustration or encounter setbacks that they might face in a mathematics lesson or while completing their homework.

In an attempt to use a measure with higher ecological validity, the CountDown behavioural task was designed to capture the students' perseverant behaviour in mathematics. The aim of this task is to reflect more realistic approaches to problem-solving employed by students in their mathematics lessons.

Example of the "CountDown" task

In this task, the students needed to use the numbers available and the four standard operations (addition, subtraction, multiplication and division) to make the target number. In each challenge, each number should only be used once. It may not be necessary to use all the numbers.

Example: Target number: 635 Available numbers: 100, 75, 25, 7, 4, 7

The students were given three "CountDown" challenges to complete. They were informed that they could switch back and forth between the three challenges or that they could stop working and instead doodle or draw if they wished. The students were given a total of ten minutes on the three CountDown challenges, although they were not aware of the total allotted time for the task. They would, therefore, have had to decide to stop working on the task and proceed to doodling or drawing without knowing how much time was left on the task. The time on task was used as a measure of perseverance, akin to the Academic Diligence Task used by Galla and colleagues (2014). The time was recorded to the nearest minute.

Measuring Cognitive Skills

The Wechsler Adult Intelligence Scale, WAIS, (2003), suitable for ages 16-99, is the most commonly used measure of cognitive skills (Duckworth, 2016). Prior to using WAIS, a number of different cognitive tests were trialled in the pilot, especially many adapted to be used on computers or iPads to reduce the variability in test administration. Unfortunately, these were not technically stable. As access to students and respect for the participants' time was of paramount importance, it was decided to use the WAIS, despite the time and cost demands that it placed on both the participants and the researcher.

As per similar studies (Finn et al., 2014; West et al., 2014), in order to reduce the burden on the participants and to make data collection more manageable, instead of the full battery, the following subtests were used:

Processing Speed was assessed using the Coding and Symbol Search Subtests from the fourth edition of the Wechsler Adult Intelligence Scale (Wechsler, 2003).

Working Memory was assessed using the Digit Span subtest from the fourth edition of the Wechsler Adult Intelligence Scale (Wechsler, 2003).

Fluid Reasoning was assessed using the Matrix Reasoning subtest the fourth edition of the Wechsler Adult Intelligence Scale (Wechsler, 2003).

These subtests are highly correlated with the composite score generated from all the subtests (Lichtenberger & Kaufman, 2009). The average time to complete the 3 subtests was around 21 minutes. The tests were administered in a quiet and private room in each school. The students completed these tests in their free lessons, only if they wanted to. As a result, only 57 out of the 100 students completed these tests, as others were either unavailable or unwilling to participate.

As well as using the scores from each cognitive skill, the three standardised scores were combined and averaged into a composite score to reflect general cognitive ability (from here on referred to as WAIS composite percentile). It was hoped that this measure would provide greater breadth and reduce measurement error (Finn et al., 2014).

5.6 Analytic Plan

To explore the two constructs of grit, and self-control and their operationalisation, descriptive statistics were closely examined and exploratory factor analyses were conducted.

Academic achievement such as GCSE grades continue to be the gatekeepers to future life outcomes by determining access to a multitude of opportunities beyond secondary school (Boliver, 2013). Hierarchical multiple linear regression analyses were used to examine the incremental validity of grit, its two dimensions and self-control for explaining the variance in average GCSE points scores, as a measure of overall academic achievement and GCSE mathematics grades as a measure of academic achievement in mathematics.

As previously discussed, it is claimed that the two constructs of grit and self-control are inextricably connected, differing in timescale and structure (see section 2.3.5 for in depth discussion). To be gritty and pursue a long-term goal, one is required to act self-controlled in the short-term and to act self-controlled one needs to regulate behaviour in service of a valued goal (Duckworth & Gross, 2014). It was, therefore, decided to treat each construct as a separate predictor, as has been the practice in similar studies (Galla et al., 2014; Muenks, Wigfield, Yang, & O'Neal, 2016; West et al., 2014). It is worth noting that grit as a composite of its two dimensions showed acceptable internal consistency, however, each dimension had a lower alpha. Since the sub-scale items were less closely related as a group, it appeared that each 4-item dimension fell short of internal consistency of the 8-item full Grit-S scale measure. The low internal consistencies observed highlight possible shortcomings of using these two dimensions as separate variables in regression analyses.

Nevertheless, given the current conclusions from the research evidence (see section 2.3.3 for in-depth discussion), it was decided to examine the validity of grit and each dimension in the regression analyses to ensure that the results were comparable to other recent studies (Muenks, Wigfield, et al., 2016; Muenks et al., 2017; Schmidt et al., 2017; Steinmayr et al., 2018).

Since the roles of cognitive ability in predicting academic achievement is well-established (Cheng & Furnham, 2012; Collins, 1984; Ferla et al., 2009; Finn et al., 2014), the students' cognitive ability was entered into regression models. Moreover, given the role of academic self-efficacy in academic achievement and the theoretical model for this research (Pajares & Schunk, 2001; Pajares, 1996; Bandura, 1997, 1986), the incremental validity of grit, its two dimensions and self-control for explaining the variance in average GCSE points scores were compared with the validity of academic self-efficacy.

As highlighted in Chapter 2, grit and self-control are predictive of achievement in challenging domains. However, predicting average academic achievement (in this case average GCSE points scores) ignores the contextual factors that impact it. Therefore, the incremental validity of grit, its two dimensions and self-control for explaining the variance in academic achievement in the challenging domain of mathematics (as measured by mathematics GCSE grade) were also examined using hierarchical multiple linear regression. This addressed the gap in the literature on domain-specificity of academic perseverance as highlighted in Chapter 2. Furthermore, self-efficacy theory proposes that self-efficacy is domain-specific. Pajares (1996) suggests:

"particularized measures of self-efficacy that correspond to the criterial tasks with which they are compared surpass global measures in the explanation and prediction of related outcomes" (p. 543).

Therefore, it was decided to use a domain-specific measure of academic self-efficacy. In this case, self-efficacy in mathematics was used to explain the variance in academic achievement in mathematics i.e. the students' GCSE mathematics grade. Finally, the incremental validity of grit, its two dimensions and self-control for explaining the variance in performance in the CountDown behavioural task were also examined and compared with self-efficacy in mathematics.

5.7 Results

5.7.1 Descriptive Statistics and Zero-order Correlations

Following the processing and harmonisation of the data from both schools (see Appendix C.1 for details), the data were entered into IBM SPSS statistics version 23. The descriptive statistics and zero-order correlations of the key variables were examined. The means, standard deviations and zero-order correlations are presented in Table 5-2.

Table 5-2 Means, standard deviations, and bivariate zero-order correlations for major variables

	1	1a	1b	2	3
1. Grit	-				
1a. Grit Consistency of Interest	.855**	-			
1b. Grit Perserverence of Effort	.835**	.428**	-		
2. Self-control	.627**	.561**	.497**	-	
3. Academic Self-efficacy	.593**	.365**	.646**	.529**	-
N	100	100	100	100	100
M	3.14	2.82	3.45	2.85	3.89
SD	.61	.74	.70	.70	.96

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The mean for grit in this study is consistent with the only UK-representative sample (N = 4,642) of 16 year olds (Rimfeld et al., 2016). The mean for *Perseverance of Effort* dimension of grit is higher (M = 3.45) than the mean for the *Consistency of Interest* dimension (M = 2.82), consistent with other US based studies with adolescent children. The mean of self-control for this study (M = 2.85) seems somewhat lower than other US-based studies of adolescent children (Duckworth & Seligman, 2005; Galla et al., 2014), that range from 3.1 to 3.76.

Wechsler Adult Intelligence Scale, WAIS, was administered to N = 57 students out of the total of 100 in this study, as a measure of cognitive ability. The mean was just below the 50th percentile, which is the average for the population. As expected, the WAIS distribution was normally distributed.

5.8 Exploring Grit and Self-control

5.8.1 Factor Analysis of Grit

The 8 items in Grit-S scale were subjected to principal components analysis (PCA), as exploratory analysis of the scale. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = .683) exceeded the recommended value of .6 and the Bartlett's Test of Sphericity value was significant ($p < .001$), supporting the factorability of the correlation matrix (Pallant, 2013a).

PCA revealed the presence of three components with eigenvalues exceeding 1, explaining 35.8%, 15.4% and 12.8 % of the variance respectively. Inspection of the scree plot showed a clear break after the second component (see Appendix C.2). The two components solution explained a total of 51% of the variance, with component 1 contributing 35.8% and component 2 contributing 15.4%. Oblimin rotation was performed to interpret the two components, with both components showing a number of strong loadings and all variables loading substantially on only one component. The items loading onto the two factors were found to be consistent with the two dimensions of grit (see Table 5-3).

The items mapped exactly with the items measuring the two dimensions of grit: *consistency of interest* (items 1, 3, 5 & 6) and *perseverance of effort* (items 2, 4, 7 & 8) as stated by the scale authors.

Table 5-3 Pattern and structure matrix for PCA with Oblimin rotation of two-factor solution of Grit-S items

Item	Pattern coefficients		Structure Coefficients		Communalities
	Component 1	Component 2	Component 1	Component 2	
8. I am diligent.	0.874	-0.007	0.872	0.242	0.760
4. I am a hardworker.	0.870	-0.069	0.850	0.179	0.727
7. I finish whatever I begin.	0.610	-0.069	0.850	0.179	0.530
2. Setbacks don't discourage me.	0.412	-0.045	0.399	0.073	0.161
5. I often set a goal but later choose to pursue a different one.	-0.215	0.777	0.238	0.768	0.555
3. I have been obsessed with a certain idea or project for a short time but later lost interest.	0.021	0.762	0.007	0.716	0.590
6. I have dificulty maintaining my focus on projects that take more than a few months to complete.	0.412	0.507	0.556	0.624	0.545
1. New ideas and projects sometimes distract me from previous ones.	0.156	0.409	0.273	0.453	0.228

5.8.2 Factor Analysis of Self-control

The 10 items in the Brief Self-control Scale were subjected to principal components analysis (PCA), as exploratory analysis of the scale. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = .775) exceeded the recommended value of .6 and the Bartlett's Test of

Sphericity value was significant (p < .001), supporting the factorability of the correlation matrix (Pallant, 2013a).

PCA revealed the presence of two components with eigenvalues exceeding 1, explaining 36.9% and 14.6% of the variance respectively. However, closer inspection of the items showed that the 3 items loading onto the second factor were the reverse coded items. It was, therefore, likely that these items were found to correlate strongly simply due to their reverse-worded nature (Zhang, Noor, & Savalei, 2016; Rosenberg, 1965). Moreover, inspecting the scree plot also confirmed a break after the first factor (see Appendix C.2), further supporting the single factor structure as suggested by the scale authors (Tangney et al., 2004). Therefore, it was reasonable to assume that self-control had a single factor.

5.9 Multiple Linear Regression Analyses

5.9.1 Testing the Assumptions for Multiple Linear Regression Analyses

Prior to undertaking multiple linear regression analysis, preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. First, any outliers were investigated and since they represented actual answers by the participants, it was decided to include them in the analyses. Moreover, the Mahalanobis distance did not exceed the critical Chi squared, indicating that the multivariate outliers were not of concern (Pallant, 2013). Inspecting the normal probability plots for the standardised residuals as well as the scatter plots of standardised residuals against standardised predicted values showed that the assumptions of normality, linearity and homoscedasticity of residuals were met.

5.9.2 Explaining the Variance in Academic Achievement

Hierarchical multiple regression was used to assess the incremental validity of grit, its two dimensions and self-control for explaining the variance in overall academic achievement (average GCSE points score across GCSE subjects). The students' school and gender did not make significant contributions and were therefore not included in the models. To capture the influence of cognitive ability on academic achievement, the students' WAIS standard score was entered in block 1 of the model, explaining a total of 3.5% of the variance in average GCSE points scores (see Table 5-4). Grit (Model 2), its two dimensions of *Consistency of Interest* and *Perseverance of Effort* (Model 3) and self-control (Model 4) made small but statistically non-significant contributions in explaining the variance in of average GCSE points scores (see section 5.6 for justifications for entering variables into the regression models). However, as expected, academic self-efficacy and WAIS standard score (Model 5) both made a significant contribution, accounting for a total of 11.3% of the variance in the scores, F (2, 51) = 3.263, p = .046. It is worth highlighting that only Model 5 was statistically significant.

Table 5-4 Results of regression analyses: Average GCSE points scores

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	35.459	6.769		28.626	8.412		28.328	8.328		35.211	8.151		27.491	7.555	
WAIS Standard Score	.094	.068	.188	.129	.073	.257	.126	.072	.250	.096	.073	.191	.126	.068	.251
Grit				1.119	.829	.195									
Grit Consistency of Interest							-.364	.763	-.075						
Grir Perseverance of Effort							1.498	.772	.300						
Self-control										.039	.700	.008			
Academic Self-efficacy													1.498	.707	.286*
R^2		.035			.069			.106			.035			.113	
Adjusted R^2		.017			.032			.052			-.002			.079	
F	F (1, 52) = 1.908			F (2, 51) = 1.879			F (3, 50) = 1.966			F (2, 51) = .937			F (2, 51) = 3.263*		

*p < .05. **p < .01. ***p < .001.

5.9.3 Explaining variance in Academic Performance in a Given Domain: Mathematics

A similar approach was used for explaining the variance in GCSE mathematics grades. As before, the students' school and gender did not make significant contributions and were therefore not included in the models. As can be seen in Table 5-5, WAIS standard score accounted for 19.0% of all variance in GCSE mathematics grades F (1, 52) = 12.193, p = .001 (Model 1). As hypothesised, grit (Model 2), its two dimensions (Model 3) and self-control (Model 4) did not make a statistically significant contribution for explaining the variance in mathematics GCSE grade. In contrast, the WAIS standard score and mathematics self-efficacy together explained 36.5% of all variance in grades with mathematics self-efficacy accounting for an additional 17.5% of the variance above and beyond WAIS standard score (Model 5).

In order to unpick whether the trait-level measures of grit and self-control fell short of explaining the variance in academic performance in mathematics due to a lack of alignment of the students' academic goals with performing academically in mathematics, the students' Maths Goal was entered in another the model. It was found that even after controlling for WAIS standard score, students' Maths Goal explained a further 9.1% of the variance in GCSE mathematics grades, accounting for a total of 28.1% of all variance. After controlling for WAIS and Maths Goal, the only variable to significantly contribute to explain the variance was found to be self-efficacy in mathematics (and not grit, its two dimensions or self-control) adding a further 12.4%. This model accounted for a total 40.5% of all variance in GCSE mathematics grades F (3, 50) = 11.339, p < .001, with the WAIS standard score(β = .037, p = .002) and mathematics self-efficacy (β = .361, p = .002) making significant contributions to the model.

Table 5-5 Results of regression analyses: GCSE mathematics grades

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	B	SE	β	B	SE	β	B	SE	β	B	SE	β	B	SE	β
Intercept	1.440	1.230		1.292	1.555		1.265	1.563		.721	1.469		.178	1.149	
WAIS Standard Score	.043	.012	.436***	.044	.013	.443**	.044	.013	.440**	.047	.013	.476**	.041	.011	.408**
Grit				.024	.153	.021									
Grit Consistency of Interest							-.070	.143	-.072						
Grir Perseverance of Effort							.095	.145	.096						
Self-control										.113	.126	.119			
Mathematics Self-efficacy													.415	.110	.420***
R^2		.190			.190			.198			.203			.365	
Adjusted R^2		.174			.159			.150			.171			.341	
F		F (1, 52) = 12.193**			F (2, 51) = 5.995**			F (3, 50) = 4.108*			F (2, 51) = 6.476**			F (2, 51) = 14.684***	

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

5.9.4 A More Granular Model

The means, standard deviations and zero-order correlations for major variables including sources of mathematics self-efficacy are presented in Table 5-6.

Table 5-6 Means, standard deviations, and bivariate zero-order correlations for major variables, including sources of mathematics self-efficacy

	1	1a	1b	2	3	4	5	6	7
1. Grit	-								
1a. Grit Interest	.855**	-							
1b. Grit Perserverence	.835**	.428**	-						
2. Self-control	.627**	.561**	.497**	-					
3. Mathematics Self-efficacy	.124	.092	.119	.081	-				
4. Mastery Experiences	.109	.119	.064	-.008	.866**	-			
5. Vicarious Experiences	.308**	.124	.405**	.238*	.642**	.444**	-		
6. Social Persuasions	.067	.032	.083	.067	.816**	.671**	.489**	-	
7. Physiological State	-.073	.011	-.139	-.031	.627**	.450**	.064	.247*	-
N	100	100	100	100	100	100	100	100	100
M	3.14	2.82	3.45	2.85	3.59	3.65	3.33	3.30	4.09
SD	.61	.74	.70	,70	.79	1.03	.95	1.14	1.18

**. Correlation is significant at the 0.01

*. Correlation is significant at the 0.05

To gain a more granular picture, the validity of four sources of mathematics self-efficacy (mastery experiences, vicarious experiences, social persuasion and physiological state) for explaining the variance in GCSE mathematics grade was explored using a hierarchical regression analysis.

The WAIS standard score was entered in block 1 and the four sources of mathematics self-efficacy added in block 2 ($\Delta R = .224$). Results demonstrated that only WAIS standard score and mastery experiences made a statistically significant contribution in explaining the variance in GCSE mathematics grade. The addition of grit and self-control in block 3 did not improve the model's explanation of variance in GCSE mathematics grade. Removing all statistically redundant variables yielded a final model, F (2, 51) = 19.127, $p < .001$, with WAIS standard score ($\beta = .039$, $p < .001$) and mastery experiences ($\beta = .404$, $p < .001$) explaining 42.9% of variance in the GCSE mathematics grades. Use of mastery experiences, instead of mathematics self-efficacy, led to a 6.4% improvement for explaining the variance in GCSE grades. More importantly, it further confirmed the key underlying source of mathematics self-efficacy in this sample: mastery experiences.

5.9.5 Findings from the Behavioural Task

The CountDown Task

Building a multiple regression model with total time on the CountDown task as the outcome variable showed that the only mastery experiences significantly was significantly associated with the total time on task, explaining 11% of all variance, F (1, 52) = 6.403, $p = .014$. Grit, its two dimensions and self-control did not make a statistically significant contribution to explaining the variance in time on task. These findings further supported the idea that the trait-level measures of grit and self-control fail to capture performance in domain-specific tasks.

5.10 Discussion

Findings for this sample demonstrated that grit, its two dimensions and self-control only made a negligible and statistically non-significant contribution to explaining the variance in academic achievement (average GCSE points scores or GCSE mathematics grades). In previous research, both constructs have been reported to predict GPA, although, they have fallen short of predicting performance in standardised tests (Duckworth & Quinn, 2009). GPA captures a student's performance in classwork, homework and grades over the course of an academic year and is perhaps a better indicator of academic behaviour over a prolonged period of time. Standardised tests, on the other hand, capture academic performance in an instance in time and are more similar to GCSEs as a summative measure of academic achievement. It is, therefore, not surprising that WAIS standard score as a measure of cognitive ability significantly contributed to explaining the variance in academic achievement and that grit and self-control fell short.

Moreover, grit requires dedication to very long-term goals and this means focusing on a single superordinate goal. At best, grit is likely to explain the variance in academic achievement, only if the learner's superordinate goal is aligned with academic achievement in GCSE exams. To address this, the students' declared intention to continue with studying mathematics beyond GCSE and in their future careers (termed Maths Goal) was drawn upon. It was found that even after controlling for the students' Maths Goal, as a representation of the alignment of their superordinate goal with academic performance in mathematics, the trait-level measures of grit and self-control failed to contribute to explaining the variance in GCSE grades.

It appears that whilst it may be beneficial later in life to settle on a single superordinate goal by narrowing one's hierarchical goals (for instance to advance one's career), this may not be desirable at a younger age. Perhaps grit does not explain the variance in average GCSE points scores, as at this point in a student's life, the goal is to perform well across many subjects rather than focus on a small number. Therefore, attempting to explain GCSE performance, using grit as a trait-level construct, may be questionable. If grit is to be used as a predictor of academic achievement, it may be more applicable to predicting A-level results or university grades, as students would have narrowed their choices and become more focused on their long-term goals. This may be more congruent with grit's *consistency of interest* dimension.

Academic self-efficacy and mathematics self-efficacy were found to be stronger predictors of overall academic achievement and achievement in mathematics respectively, in agreement with previous research (Steinmayr et al., 2018; Muenks, Wigfield, et al., 2016; Pajares, 1996; Collins, 1984). These findings demonstrate the need for measures of perseverance that are designed to capture perseverance in academic settings in adolescents, rather than trait-level measures of perseverance. It was found that academic self-efficacy accounted for 5.9% of all variance in the average GCSE points score, while mathematics self-efficacy accounted for 16.5% of GCSE mathematics grade. In line with self-efficacy theory, these findings suggest that the incremental validity of self-efficacy measures improves by narrowing their specificity to the domain (Bandura, 1997; Pajares, 1996).

A number of researchers including Galla and colleagues (2014) have suggested using tasks similar to the CountDown task to study perseverance in a domain. Yet, grit and self-control did not make a statistically significant contribution to explaining the variance in time on the CountDown task, while mathematics self-efficacy explained 11% of all variance. This finding further supports the idea that grit and self-control, as trait-level measures, fail to capture performance in domain-specific tasks.

5.10.1 Limitations and Implications for Study 2

Whilst there are a number of implications of the findings from this study, it is important to consider some of the limitations. First, it is worth noting that the GCSE grades were not measures of the students' current achievement (at the time of data collection) but of GCSE exams taken 3 months prior. This was the only way to compare academic achievement amongst all participants, since students' post-16 paths diverge, making it impossible to draw comparisons in academic achievement. To overcome this shortcoming, the students' current school grades were collected in Study 2.

Second, the sample size in this study was limited by access to participants and time constraints. In particular, administering the cognitive ability tests (WAIS) placed a great time demand on the participants and felt very effortful for most. As a result, only 57 students completed the WAIS, even though 100 surveys were completed, resulting in a small sample for the regression analyses. The small size of the subgroup means that the findings relating particularly to the WAIS cannot be generalised beyond the sample. In Study 2, the participants' Cognitive Ability Test (CAT) scores administered in year 7 were obtained from each school.

Moreover, while there were distinct advantages to using Sixth Form participants in this study, there were also some disadvantages. Most obviously, Sixth Form students choose to stay in full-time education (instead of pursuing other vocational alternatives such as apprenticeships) and therefore, are likely to represent students with higher academic ability beliefs and perhaps higher cognitive ability. For Study 2, the survey will, therefore, be administered to a larger and more representative sample of students from different year groups.

Additionally, conducting empirical research in the school setting also allowed me to understand the limitations of instruments or surveys and the complexities of research in schools. As the cross-sectional design relied mainly on self-report surveys, it carried limitations associated with their use such as social desirability bias. This shortcoming of self-report instruments highlighted the need for use of other measures, such as behavioural engagement tasks or attendance data as suggested by other researchers (Duckworth & Yeager, 2015; Jackson, 2012).

Despite the limitations, the findings for this study resulted in a number of other decisions being made as to how to pursue the aims of this programme of research. These findings provided tentative support for using school-specific measures of perseverance to capture academic perseverance amongst adolescents in school settings, since it was found that grit, its two dimensions and self-control, as trait-level measures of perseverance, failed to make a contribution in explaining the variance in of GCSE grades (while academic self-efficacy significantly contributed to explaining the variance in GCSE grades even after controlling for cognitive ability).

Therefore, the focus of Study 2 will be to adapt the current measures of grit and self-control to capture perseverance in academic settings, in line with the theoretical framework for this research. These adapted school-specific measures will allow a closer examination of the dynamic relationship between a person and their academic context, in order to capture some of the systemic complexities. In the next phase of the research, the incremental validity of the adapted school-specific measures of perseverance can be examined in order to confirm these initial findings. Furthermore, to deepen the current understanding of academic perseverance in adolescents, the incremental validity of these measures will be extended to explaining the variance in academic behaviours such as attendance.

The design of the behavioural engagement task, CountDown, was based on similar behavioural tasks, with the goal of improving ecological validity by creating more realistic problem-solving demands for the students. However, since the task was purely number based and relied on the students' mental arithmetic, this task was found to be imperfect for measuring perseverance in students due to the variability in mental arithmetic skills. As a result, future behavioural tasks need to be designed with this in mind. These tasks will not rely the students' prior knowledge in mathematics (see section 9.5.2 for an in depth discussion) and will use visual mathematics problems as recommended by leading researchers in the field (Boaler, 2016; West, 2004). Reflecting on these findings, it is apparent that investing time to design a behavioural task for the main studies in this research has the potential to be a useful approach in the study of academic perseverance.

Finally, it was found that the students' declared Maths Goal provided meaningful insights into the students' academic/ career goals and made a significant contribution to explaining the variance in academic achievement in mathematics. This finding suggests that refining and using such a measure for the study of perseverance in mathematics is worthwhile.

Chapter 6: The Large-scale Survey

6.1 Background and Rationale

Evidence suggests that for many adolescents poor academic perseverance negatively impacts academic achievement, as well as post-16 academic and career opportunities (for reviews see: Dweck, Walton, & Cohen, 2014; Farrington et al., 2012; Gutman & Schoon, 2013; Nagaoka et al., 2014; Hurst & Cordes, 2017; Rosenzweig & Wigfield, 2016). Despite, the central role of academic perseverance in future academic and career opportunities, there still remains a lack of clarity in its conceptualisation and operationalisation amongst researchers. In fact, most studies to date operationalise perseverance using trait-level measures of grit and self-control, instead of measures that are specific to academic settings. Grit and its two dimensions - *perseverance of effort* and *consistency of interest* - claim to address both aspects of adolescents' perseverance in school: working hard day to day and maintaining academic interest beyond secondary school (Dweck et al., 2014; Farrington et al., 2013). Grit's promise of capturing both aspects has made it especially appealing for researchers and educators (Credé et al., 2016; Muenks, Wigfield, et al., 2016; Rimfeld et al., 2016). Nevertheless, it is important to acknowledge that treating the two dimensions of grit as a composite construct may be blurring the picture, making it difficult to examine the underlying processes affecting academic perseverance amongst adolescents (Steinmayr et al., 2018; Schmidt et al., 2017; Muenks et al., 2017). Furthermore, the theoretical framework for this research highlights the importance domain-specificity (see Chapter 3 for in depth discussion). This view suggests that domain-specific measures of academic perseverance are likely to be superior to trait-level or even school-specific constructs since they better capture the complexities and the interactions between adolescent students and their context (Pajares & Schunk, 2001; Bandura, 1997; Pajares, 1996).

Furthermore, Study 1 of this research programme demonstrated that grit, its two dimensions and self-control, as trait-level measures of perseverance, did not to make a statistically significant contribution to explaining the variance in academic achievement (as measured by grades and a behavioural task) in adolescents in England. Therefore, for the large-scale survey, these measures were adapted to be specific to school with the hope of increasing their incremental validity. If these school-specific measures explain variance beyond the trait-level measures, this would suggest that using school or subject-specific measures will likely provide a clearer understanding of the role of grit, its two dimensions and self-control for explaining the variance in academic achievement in different contexts (Cormier, Dunn, & Causgrove Dunn, 2019; Duckworth & Quinn, 2009; Schmidt et al., 2017). This has also been the approach taken in a recent study of German adolescents, supporting the use of adapted school-specific measures in the present study (Schmidt et al., 2017).

To address the aforementioned research problems and the gap in the current research, three studies were undertaken using the data from the large-scale survey. Study 2a examined the incremental validity of school-specific grit and self-control for explaining the variance in academic achievement. Study 2b further addressed a gap in the research by comparing the incremental validity of school grit and school self-control, with measures of perseverance in mathematics as a school subject. Moreover, by examining the impact of academic perseverance for explaining the variance in other meaningful indicators such as the students' future academic intentions and goals, it was possible to gain an understanding of the measures' impact on broader academic outcomes, beyond grades. This is of special importance since most studies to date have been solely focused on grades. Finally, Study 2c addressed the underlying mechanisms affecting perseverance in mathematics amongst adolescents in England.

6.2 Aims and Objectives

The overarching aim of studies 2a, 2b and 2c was to gain a deeper understanding of *academic* perseverance amongst adolescents in England.

This aim was achieved through the following objectives, in the three separate studies:

- By adapting the Grit-S and the Brief Self-control Scales to capture perseverance at school (i.e. school-specific rather than trait-level measures of perseverance)
- By examining the incremental validity of these adapted school-specific measures of perseverance (Study 2a) for explaining the variance in grades and school attendance
- By comparing the incremental validity of school-specific grit and school self-control with measures of perseverance in mathematics (Study 2b)
- By examining the impact of perseverance beyond grades and exploring their associations with the students' future academic intentions and goals (Study 2b)
- By examining potential predictors of perseverance in mathematics (Study 2c)

6.3 Methods

6.3.1 Participants

The participants in this study were selected from two mixed comprehensive schools in England. A total of 1,461 students took part in this research and completed the survey. Of those, thirteen students were excluded as they (eleven students) or their parents (two students) did not consent to participating in the research. The final sample comprised of 1448 students (*M* age = 14.0 years, *SD* = 1.1). The table below summarises sample characteristics:

Table 6-1 Sample characteristics for the large-scale survey

Sample Characteristics	School 1	School 2	Overall Sample
Mean Age	13.8	14.3	14.0
Female	47.4%	46.2%	47.0%
Free School Meals Ever Status	12.7%	20.7%	15.9%
English as an Additional Language Status	2.2%	19.6%	8.8%
Special Educational Needs Status	15.4%	13.5%	13.6%
Year 7 Cognitive Ability Test Mean Score	106.0	103.0	105.3
Key Stage 2 Reading, Writing & Mathematics Mean Score	29.8	29.7	29.8

6.3.2 Procedure

The participants were recruited though their schools, with a parent information sheet and opt out consent letter sent home prior to the study being carried out. On the first day of data collection, the students' written consent was also obtained, following an information session. After a brief introduction to the study in their mathematics lessons, the students were asked to complete a pen and paper survey containing demographic information, as well as a series of self-report scales. This took around 30 minutes to complete. The survey was administered to all students in years 7, 8, 9 and 10 (who consented to participating in the study, and whose parents had already consented to them participating). This enabled the researcher to capture students of all abilities within each year group. Furthermore, the schools in the study expressed a preference for including all students in each year group to avoid students feeling left out. Upon the completion of the survey, the participants were debriefed with the details of the complaint procedure and the right to withdraw from the study. The survey data was collected in June 2017. The students' demographic data and grades were provided by the schools (with parental consent) in June 2017 and nine months later in April 2018.

6.3.3 Measures

Figure 6-1 shows the measures used in the pen and paper survey. Since the focus of this research was academic perseverance, trait-level measures of grit and self-control were adapted to reflect a student's perseverance in school. In line with similar studies, students were asked to answer the questions by considering each item in relation to their school work (Schmidt et al., 2017), by adding the words "In school" to each item. Initially, it was planned to use "In my academic pursuit" instead of "In school". This is because "In school" is more encompassing and may bring to the participants' minds the wider aspects of school life beyond academics. However, "In my academic pursuit" was not as accessible for younger students. Measures specific to mathematics were also drawn upon to examine perseverance in mathematics. These will be discussed in greater detail in Chapter 7.

Demographics, Academic Attainment and Cognitive Ability

Participants were asked to report their date of birth and gender. The schools provided other demographic data on the students' Special Educational Needs (SEN), English as an Additional Language (EAL) and Free School Meals Ever (FSM Ever) status at the time of data collection (June 2017). As a measure of prior attainment, the students' Key Stage 2 results were provided for Reading, Writing and Mathematics. Furthermore, the students' Cognitive

Ability Test scores, administered in year 7, as a measure of general cognitive ability were supplied by the school. Year 7 Mean CAT scores and KS2 results were not available for all students. In April 2018, one of the schools was able to provide an average of each students' current grades in their GCSE courses (similar to average GCSE points scores used in Study 1) for the students in years 10 and 11. Since the GCSE criteria was used to generate these scores across all subjects, this average score was a more reliable measure of overall academic performance and was used to examine the incremental validity of school grit, its two dimensions and self-control of overall future academic achievement.

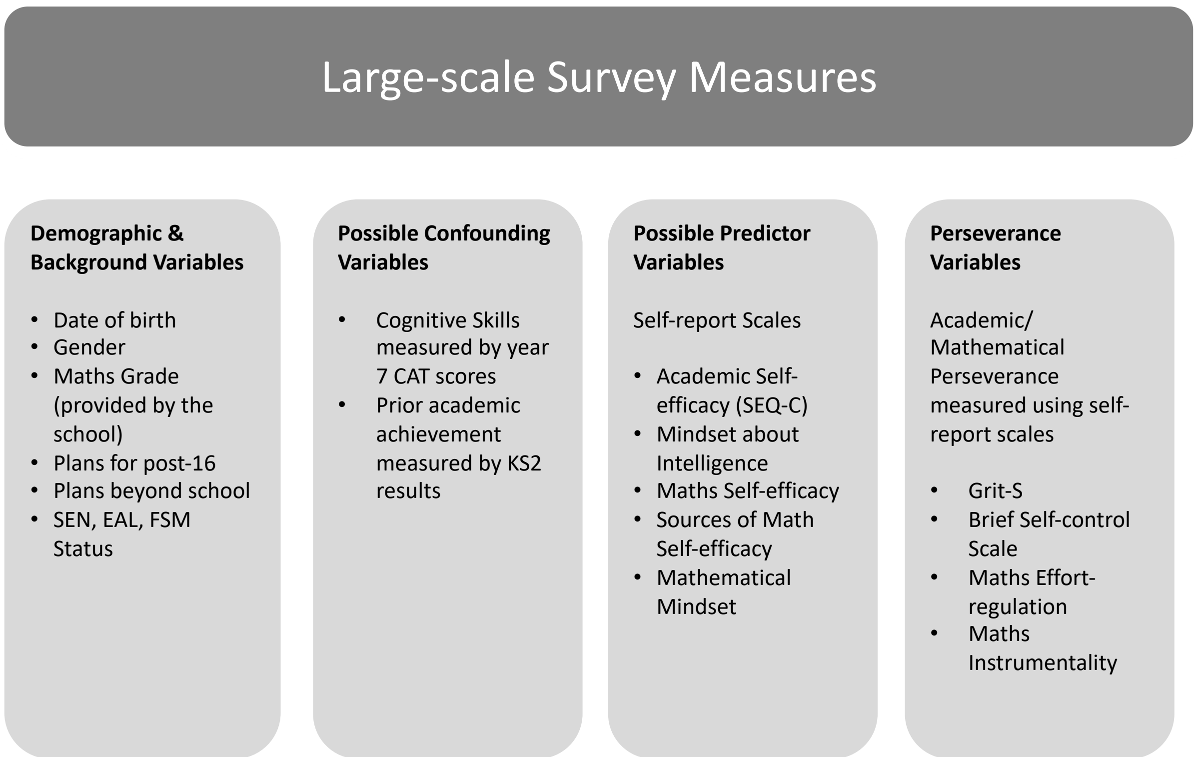

Figure 6-1 Measures used in the large-scale survey

6.3.4 Self-report Measures

School Grit

To capture school-specific grit (as opposed to trait-level grit), the 8-item Short Grit Scale was modified by asking the students to considering each item in relation to their school work

(Schmidt et al., 2017). The adapted 8-item Short Grit Scale (Duckworth & Quinn, 2009) was administered to participants who rated how much they identified with the items using a 5-point scale (1 = not like me at all to 5 = very much like me). In this scale, four items measure students' *consistency of interest* (e.g., "I often set a goal but later choose to pursue a different one"), and four items measure students' *perseverance of effort* (e.g., "I am diligent"). A high score indicated high grit (α = .69).

School Self-control

Similarly, the 10-item Brief Self-control Scale (Tangney, Baumeister & Boone, 2004) was adapted to reflect school-specific self-control (as opposed to self-control as a global trait). The students were asked to answer the questions by considering each item in relation to their school work. The adapted scale was used to measure the individual differences in self-control in participants with the same 5-point scale. A high score indicated high self-control (α = .82).

Academic Self-efficacy

The Academic Self-efficacy Subscale from Self-efficacy Questionnaire for Children (SEQ-C, Muris, 2001) was used, with participants rating general perceived academic ability on a 5-point scale (1 = not at all to 5 = very well). A high score indicated high academic self-efficacy (α = .79).

Mindset about Intelligence

The 4-item mindset self-report scale (Farrington et al., 2013) was used to determine a learner's implicit mindset about intelligence with participants rating their mindset on a 5-

point scale (1 = not at all true to 5 = completely true). A high score indicated a growth mindset, whereas a low score indicated a fixed mindset (α = .73).

6.4 Data Entry, Data Harmonisation and Processing

Given the large number of participants, the data entry was a lengthy and laborious process, taking around eight weeks to complete. To ensure that data was correctly entered, 50 participants' survey data were randomly selected and checked. Only minor errors were detected with single item entries. To check the coding, the survey data for 20 participants was randomly selected and manually coded and compared with the processed data. No errors were found in the coding.

Following the challenges faced in Study 1 for harmonising the data from the two schools, it was decided to invest time to understand the available data and its format at each school. Prior to data collection, two meetings were held with each school's data manager. It was, therefore, possible to get the data in compatible formats from both schools from the outset. This made the task of harmonising the data far easier.

The main challenge was harmonising the school grades. It would have been desirable to obtain a measure of overall academic performance, such as the average GCSE points scores used in Study 1. Since those grades were from a recognised national examination, they were comparable between schools and students. Unfortunately, since students in years 7, 8, 9 and 10 were not taking national examinations, the only available grades were each school's internal subject grades. To make matters more complicated, the official grading system for GCSE Mathematics and English were replaced for the Summer 2017 GCSE examinations. The grades A* to U were no longer applicable and were replaced by grades 9 to 1. The grade C which was used for calculating key school success metrics (e.g. percentage

A*- C grades), now fell somewhere between a grade 4 and a grade 5. This had a significant and rather unsettling effect for the staff. To overcome the uncertainties related to the new grading system, these departments in both schools decided to adopt this new grading system and applied it to grading all students from years 7 to 11. There was close agreement between the two schools as to how to apply the new grading system in mathematics from years 7 to 11. Nevertheless, at the time the data was collected in June 2017, heads of department and staff in both departments expressed a lack of confidence in their ability to correctly judge and use the new grading system. This was a key concern for using the mathematics grades for analyses.

Furthermore, since other departments in each school were still using the old grading system, it was not possible to calculate a reliable measure of overall academic performance (even within each school) for all year groups. To overcome this, in April 2018, one of the schools was able to provide an average of each students' current achievement on their GCSE courses (similar to average GCSE points scores used in Study 1) for the students in years 10 and 11. Since the GCSE criteria was used to generate these grades across all subjects, this average score was a more reliable measure of overall academic performance and it was, therefore, possible to use it to examine the incremental validity of school grit, its two dimensions and school self-control of overall future academic performance.

Following data entry, it was found that 0.3% of individual item responses were missing. This was due mainly to one of two reasons: firstly, participants missed one of the 24 items on the Sources of Mathematics Self-efficacy scale. As these items were all printed on a single page, it appeared that some participants lost their place and missed out a single item. Secondly, it was found that some students missed the back page of the survey entirely and as a result did not complete some of the mathematics instruments. In either case, it can be argued that these missing responses were random, and the participants did not differ from others in any systematic way. As the sample was very large, it was decided to use listwise deletion in SPSS to deal with any missing values (Field, 2013).

In deciding on outliers, defined as cases with a standardised residual of more than +/- 3.3 (Tabachnick & Fidell, 2013), the box plots were inspected and then the participants' responses in their booklet were referred to. It was found that in each case, the responses were intended by the participants and it was, therefore, decided to include the outliers in the analyses.

6.5 Study 2a - School Grit and School Self-control

The aim of this study was to firstly examine the adapted measures of school grit, its two dimensions and school self-control for measuring perseverance in *school* amongst adolescents. Furthermore, the incremental validity of these adapted measures for explaining the variance in school grades was investigated.

6.5.1 Research Questions and Hypotheses

The key research questions addressed in this study were:

RQ1: To what extent do school grit and school self-control explain the variance in overall academic achievement in adolescents?

RQ2: To what extent do school grit and school self-control explain the variance in achievement in mathematics (as a school subject) in adolescents?

RQ3: To what extent do school grit and school self-control explain the variance in school attendance in adolescents?

It was hypothesised that school grit and school self-control, as measures of academic perseverance, would make a greater contribution to explaining the variance in of academic achievement and attendance in secondary school students, compared with trait-level measures (as examined in Study 1).

6.5.2 Analytic Plan

To date, much of the research has focused on trait-level measures of perseverance to explain academic performance. In order to capture ***academic*** perseverance, the trait-level measures of grit and self-control were, therefore, adapted to examine perseverance in ***school*** amongst adolescents. These adapted measures were subjected to factor analyses to inspect their structures and their psychometric properties were compared to trait-level measures. To determine whether school grit and school self-control should be treated as two distinct constructs, exploratory factor analysis was undertaken using all the school grit and school self-control items to examine their factor loadings.

Moreover, the incremental validity of school grit, its two dimensions and school self-control were examined, by focusing on explaining the variance in:

- Average GCSE grades across all school subjects for students in years 10 and 11 (9 months after the survey)
- Mathematics grades for all year groups (at the same time as the survey)
- GCSE mathematics future grades for students in years 10 and 11 (9 months after the survey)
- Difference between GCSE mathematics grade and personal target grades for students in years 10 and 11 (9 months after the survey)

- Attendance for all year groups (at the same time as the survey)

6.5.3 Descriptive Statistics and Zero-order Correlations

The means, standard deviations and zero-order correlations are presented in Table 6-2. Since the two key measures of academic perseverance, school grit and school self-control, were modified by asking the learners to consider each item as it relates to their school work, it was important to draw comparisons between these modified measures and the trait-level measures used in previous studies. In this study, the means for school grit and its two dimensions, *consistency of interest* and *perseverance of effort*, were consistent with other studies of school-age children (Eskreis-Winkler et al., 2014; Muenks, Wigfield, et al., 2016), including the largest UK-representative sample (*N* = 4,642) of 16 year olds (Rimfeld et al., 2016). The mean of school self-control for this study was also consistent with the studies of school-age children (Duckworth & Seligman, 2005; Galla et al., 2014), that range from 3.1 to 3.76. The mean standardised age score for year 7 CAT scores appeared slightly higher than the national mean of 100.

Table 6-2 Means, standard deviations, and bivariate zero-order correlations for major variables

	1	1a	1b	2	3	4	5	6	α
1. Grit	-								.687
1a. Grit Interest	.815**	-							.558
1b. Grit Perseverance	.805**	.311**	-						.718
2. Self-control	.615**	.459**	.539**	-					.818
3. Academic Self-efficacy	.595**	.330**	.638**	.603**	-				.794
4. Mindset about Intelligence	.361**	.268**	.317**	.393**	.430**	-			.732
5. Year 7 Mean CAT Score	.081**	.000	.133**	.118**	.306**	.245**	-		
6. KS2 Reading-Writing-Maths Fine	.088**	-.011	.154**	.078**	.292**	.225**	.825**	-	
N	1448	1448	1448	1448	1448	1448	1145	1118	
M	3.32	3.09	3.55	3.14	3.42	3.90	105.27	21.81	
SD	.59	.74	.72	.72	.67	.87	12.28	3.76	

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Factor Analysis of School Grit

The 8 items in the adapted school Grit-S scale were subjected to principal components analysis (PCA) using SPSS version 24, as exploratory analysis of the scale. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = .738) exceeded the recommended value of .6 and the Bartlett's Test of Sphericity value was significant ($p < .001$), supporting the factorability of the correlation matrix (Pallant, 2013a).

PCA revealed the presence of two components with eigenvalues exceeding 1, explaining a total of 50.4% variance, with each component explaining 33.3% and 17.1 % of the variance respectively. Inspecting the scree plot also confirmed a break after the second factor (See Appendix D.1). Oblimin rotation was performed to interpret the two components, with both components showing a number of strong loadings and all variables loading substantially on only one component. The results were consistent with the two dimensions of grit.

Table 6-3 School grit pattern matrix for PCA with direct Oblimin rotation with Kaiser normalisation

Item	Pattern coefficients		Communalities
	Perseverance of Effort	Consistency of Interest	
In school, …			
1. New ideas and projects sometimes distract me from previous ones.	.046	**.601**	.377
2. Setbacks don't discourage me.	**.609**	-.108	.353
3. I have been obsessed with a certain idea or project for a short time but later lost interest.	-.015	**.720**	.514
4. I am a hardworker.	**.831**	-.009	.687
5. I often set a goal but later choose to pursue a different one.	-.145	**.685**	.445
6. I have dificulty maintaining my focus on projects that take more than a few months to complete.	.268	**.550**	.442
7. I finish whatever I begin.	**.618**	.220	.493
8. I am diligent.	**.847**	.011	.721

As can be seen from Table 6-3, the items mapped clearly with the two dimensions of grit: *Consistency of Interest* (items 1, 3, 5 and 6) and *Perseverance of Effort* (items 2,4,7 and 8), in agreement with the original scale authors' two factors.

Factor Analysis of School Self-control

Similarly, the 10 items in school-specific Brief Self-control scale were subjected to principal components analysis (PCA). Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = .874) exceeded the recommended value of .6 and the Bartlett's Test of Sphericity value was significant ($p < .001$), supporting the factorability of the correlation matrix (Pallant, 2013a).

PCA revealed the presence of two components with eigenvalues exceeding 1, explaining a total of 50.9% variance, with each component explaining 38.7% and 12.2 % of the variance respectively. However, as with trait-level self-control, closer inspection of the items showed 3 items (items 4, 5 and 6) loading onto a second factor (see Table 6-4). Since these items were reverse-worded, it was likely that they correlated strongly simply due to their reverse-worded nature (Zhang, Noor, & Savalei, 2016; Rosenberg, 1965). Moreover, inspecting the scree plot also confirmed a break after the first factor (see Appendix D.1), further supporting the single factor structure as suggested by the scale authors (Tangney et al., 2004). Therefore, it was reasonable to assume that self-control had a single factor.

Table 6-4 School self-control pattern matrix for PCA with direct Oblimin rotation with Kaiser normalisation

Item	Pattern coefficients		Communalities
	1	2	
In School …			
1. I have a hard time breaking bad habits.	**.577**	.045	.356
2. I get distracted easily.	**.677**	.043	.484
3. I say inappropriate things.	**.705**	-.096	.453
4. I refuse things that are bad for me, even if they are fun.	-.113	**.803**	.585
5. I'm good at resisting temptation.	.052	**.784**	.651
6. People would say that I have very strong self-discipline.	.157	**.621**	.489
7. Pleasure and fun sometimes keep me from getting work done.	**.635**	.047	.429
8. I do things that feel good in the moment but regret later on.	**.684**	.025	.483
9. Sometimes I can't stop myself from doing something, even if I know it is wrong.	**.764**	.036	.607
10. I often act without thinking through all the alternatives.	**.760**	-.047	.551

As previously discussed, as the two constructs of grit and self-control are related (to be gritty and pursue a long-term goal, one is required to act self-controlled in the short-term and to act self-controlled, one needs to regulate behaviour in service of a valued goal; Duckworth & Gross, 2014). Therefore, exploratory factor analysis was conducted to determine that despite being related the two constructs were actually distinct.

The 18 items in school Grit-S and the school Brief Self-control scale were also subjected to principal components analysis (PCA). Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = .896) exceeded the recommended value of .6 and the Bartlett's Test of Sphericity value is significant ($p < .001$), supporting the factorability of the correlation matrix (Pallant, 2013a).

The 4-factor solution accounted for 52% of all variance. As per the school self-control factor analysis, self-control items 1, 2, 3, 7, 8, 9 and 10 loaded onto factor 1, accounting for 29.9% of variance, *perseverance of effort* grit items (2, 4, 7, 8) and self-control item 6 loaded onto factor 2, making an additional 9.1% contribution. Factor 3 was made up of grit *consistency of effort* items (1, 3, 5 and 6) adding 7.1% and self-control items 4 and 5 loaded onto the fourth factor, adding 5.8% to the overall variance (see Table 6-5). It appeared that with the exception of self-control item 6, all factor loadings were consistent with the principal component analyses that were undertaken for each of the constructs of school grit and self-control.

Table 6-5 Pattern matrix for PCA with direct Oblimin rotation with Kaiser normalisation

Item	Pattern coefficients				Communalities
	1	2	3	4	
Grit1	.066	-.182	**.524**	-.241	.406
Grit2	-.097	**-.536**	-.011	.211	.337
Grit3	-.028	-.025	**.743**	-.020	.546
Grit4	.098	**-.798**	-.084	-.008	.675
Grit5	.021	.195	**.684**	.171	.487
Grit6	.281	-.188	**.420**	-.014	.435
Grit7	-.065	**-.620**	.256	.018	.484
Grit8	.154	**-.798**	-.089	-.026	.713
SC1	**.504**	-.018	.147	.046	.343
SC2	**.531**	-.356	.082	-.170	.566
SC3	**.716**	-.048	-.104	-.102	.484
SC4	.050	-.093	-.025	**.757**	.627
SC5	.136	-.197	.053	**.652**	.602
SC6	.119	**-.454**	.015	.342	.458
SC7	**.514**	-.103	.196	.020	.431
SC8	**.689**	.143	.095	.177	.535
SC9	**.814**	.055	-.064	.116	.650
SC10	**.778**	.002	-.054	-.001	.580

The primary goal of conducting this exploratory factor analysis was to check the soundness of the decision to treat the two constructs of school grit and school self-control separately. It was also worth considering that a larger number of items tend to generate a higher number of factors (Drolet & Morrison; 2001). Reflecting on these results, it was concluded that each construct should be treated as a separate outcome variable, as has been the practice in previous studies (West et al., 2016; Muenks, Wigfield, Yang, & O'Neal, 2016; Duckworth & Gross, 2014; Credé, Tynan, & Harms, 2016).

6.5.4 Testing the Assumptions for Multiple Linear Regression: Explaining the Variance in Academic Achievement

Prior to undertaking multiple linear regression analyses, preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. The Mahalanobis distance did not exceed the critical Chi squared, indicating that the multivariate outliers were not of concern (Pallant, 2013b). The outliers were investigated and since they represented actual answers by the participants, it was decided to include them in the analyses. Inspecting the normal probability plots for the standardised residuals as well as the scatter plots of standardised residuals against standardised predicted values showed that the assumptions of normality, linearity and homoscedasticity of residuals were met.

6.5.5 Incremental Validity of School Grit and School Self-control for Explaining Future Academic Achievement

The incremental validity of school grit and school self-control, instead of trait-level measures of perseverance, for explaining the variance in academic achievement across all school subjects were examined. Due to changes to the grading criteria, instead of averaging the grades from all subjects for each student, average grades in GCSE courses were used (provided by School 2 nine months after data collection). Using hierarchical multiple linear regression, possible confounding variables such as: school, gender, year group, Special Educational Needs, English as an Additional Language and Free School Meals Ever Status, the students’ Key Stage 2 percentile rank, as a measure of prior academic attainment, and Year 7 CAT mean score as a measure of general cognitive ability were entered in block 1, accounting for 77.1% of all variance in future average GCSE grades, as an indicator of future overall academic achievement (see Model 1 in Table 6-6). The two dimensions of school grit only added 0.5%, with the *Consistency of Interest* dimension (Model 2) not making a significant contribution in explaining the variance in future average GCSE grades. School grit, as a composite measure, only added 0.5% (Model 3), and school self-control alone accounted for an additional 0.8% in explaining the variance in future average GCSE grades (Model 4).

In Table 6-7, academic self-efficacy and mindset about intelligence were added to the model, adding 2.3% in explaining the variance in future average grades (see Model 2). After controlling for academic self-efficacy and mindset, school grit, its two dimensions and school self-control no longer made a significant contribution in explaining the variance in future average GCSE grades.

Table 6-6 Regression models explaining the variance in future academic achievement across all GCSE subjects – April 2018, School 2

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-6.150	.812		-6.939	.850		-6.893	.848		-6.815	.819	
Male	-.516	.078	-.174***	-.519	.077	-.175***	-.524	.077	-.177***	-.493	.077	-.166***
Year Group	.179	.079	.060*	.202	.078	.068*	.199	.078	.067*	.179	.077	.060*
SEN Status	.036	.101	.010	.063	.101	.017	.063	.101	.017	.058	.100	.016
EAL Status	.191	.102	.050	.128	.104	.034	.131	.104	.034	.135	.102	.035
FSM Ever6 Status	-.298	.100	-.081**	-.286	.100	-.078**	-.290	.100	-.079**	-.260	.099	-.071**
Mean CAT Score	.032	.006	.278***	.033	.005	.283***	.033	.005	.285***	.033	.005	.282***
Mean KS2 Level	.224	.018	.602***	.220	.018	.591***	.220	.018	.591***	.224	.018	.601***
Grit Consistency of Interest				.061	.051	.032						
Grit Perseverance of Effort				.134	.058	.063*						
Grit							.187	.068	.074**			
Self-control										.201	.056	.094***
R^2		.771			.777			.776			.780	
Adjusted R^2		.766			.771			.771			.774	
ΔR adj ^2					.005			.005			.008	
F		*F* (7,341)= 164.179***			*F* (9,339)=130.988***			*F* (8,340)= 147.381***			*F* (8,340)= 150.275***	

$*p < .05$. $**p < .01$. $***p < .001$.

Table 6-7 Regression models explaining the variance in future academic performance across all GCSE subjects – April 2018, School 2

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-6.150	.812		-6.935	.786		-6.768	.819		-6.772	.816		-6.979	.797	
Male	-.516	.078	-.174***	-.496	.074	-.167***	-.491	.075	-.166***	-.491	.075	-.166***	-.494	.075	-.167***
Year Group	.179	.079	.060*	.183	.075	.062*	.177	.076	.060*	.177	.076	.06*	.182	.075	.062*
SEN Status	.036	.101	.001	.076	.097	.021	.071	.097	.019	.071	.097	.019	.077	.097	.021
EAL Status	.191	.102	.050	.088	.099	.023	.098	.100	.026	.098	.100	.026	.086	.100	.023
FSM Ever6 Status	-.298	.100	-.081**	-.285	.096	-.078**	-.286	.096	-.078**	-.286	.096	-.078**	-.282	.097	-.077**
Mean CAT Score	.032	.006	.278***	.030	.005	.259***	.030	.005	.256***	.030	.005	.256***	.030	.005	.26***
Mean KS2 Level	.224	.018	.602***	.211	.018	.566***	.211	.018	.566***	.211	.018	.567***	.211	.018	.568***
Academic Self-efficacy				.268	.068	.116***	.297	.081	.128***	.295	.078	.127***	.255	.077	.11***
Mindset				.125	.046	.075**	.130	.048	.079**	.131	.047	.079**	.122	.047	.073*
Grit Consistency of Interest							-.027	.052	-.014						
Grit Perseverance of Effort							-.034	.066	-.016						
Grit										-.059	.079	-.023			
Self-control													.024	.065	.011
R^2		.771			.794			.795			.795			.795	
Adjusted R^2		.766			.789			.788			.789			.788	
ΔR adj ^2					.023			-.001			0			-.001	
F	*F*(7,341)=164.179***			*F*(9,339)=145.600***			*F*(11,337)=118.674***			*F*(10,338)=130.925***			*F*(10,338)=130.717***		

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

6.5.6 Incremental Validity of School Grit and Self-control for Explaining School Attendance

As discussed, in this study, student grades across all subjects representing overall academic achievement were only available from one school, nine months after the initial survey data was collected. Due to this limitation, it was decided to ask both schools to provide the students' attendance percentages as another school-specific measure of perseverance (Duckworth & Yeager, 2015; Jackson, 2012). In recent years, it has been recommended to assess the incremental validity of constructs by going beyond grades and by using more ecologically valid measures such as attendance and school behaviour (Duckworth & Yeager, 2015; Yeager, Bryk, Muhich, Hausman, & Morales, 2013; Farrington, Levenstein, & Nagaoka, 2013; Jackson, 2012). Schools in the UK are legally obliged to keep accurate attendance records and report them to the Department for Education. As a result, using percentage attendance to test the incremental validity of school grit, its two dimensions and self-control was a meaningful and robust alternative to average school grades across all subjects.

As can be seen in Table 6-8, demographic measures, prior attainment and cognitive ability only explained 8.1% of all variance in attendance. The addition of school grit (Model 2) added a further 0.2%, whereas the two dimensions of grit in Model 3 added 0.6% with only *perseverance of effort* making a significant contribution. In Model 4, school self-control made a 0.8% significant contribution in explaining the variance in attendance beyond demographic measures, prior attainment and cognitive ability. As the only other two significant variables, it was found that Special Educational Needs status negatively correlated with percentage attendance, while KS2 average grade was positively correlated to percentage attendance. In a further model, after controlling for academic self-efficacy and mindset, school grit, its two dimensions and school self-control failed to make a significant contribution in explaining the variance in percentage attendance, while academic self-efficacy accounted for 1% (p = .021) of the variance in percentage attendance.

Table 6-8 Regression models explaining the variance in percentage attendance – June 2017, both schools

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	89.990	1.939		88.357	2.094		88.448	2.090		88.084	2.011	
School 2	-.137	.275	-.015	-.073	.277	-.008	-.087	.276	-.010	-.129	.274	-.014
Male	.155	.260	.017	.166	.260	.019	.198	.259	.022	.263	.261	.029
Year Group	-.066	.157	-.012	-.042	.157	-.008	-.034	.157	-.006	-.053	.156	-.010
SEN Status	-1.441	.312	-.144***	-1.423	.312	-.142***	-1.448	.311	-.145***	-1.417	.311	-.141***
EAL Status	.133	.456	.009	.039	.458	.003	.001	.457	.000	.012	.455	.001
FSM Ever6 Status	-.517	.357	-.043	-.490	.357	-.041	-.457	.356	-.038	-.408	.357	-.034
Y7 Mean CAT Score	.018	.019	.049	.019	.019	.051	.018	.019	.049	.017	.019	.046
KS2 Mean Level	.174	.064	.146**	.166	.064	.140**	.157	.064	.132*	.171	.063	.144**
Grit				.455	.223	.060*						
Grit Consistency of Interest							-.118	.184	-.019			
Grit Perseverance of Effort							.589	.189	.095**			
Self-control										.617	.183	.098***
R^2		.081			.085			.089			.091	
Adjusted R^2		.075			.077			.081			.083	
ΔR adj^2					.002			.006			.008	
F	F(8, 1109)=12.292***			F(9, 1108)=11.423***			F(10, 1107)=10.876***			F(9, 1108)=12.290***		

*$p < .05$. **$p < .01$. ***$p < .001$.

6.5.7 Incremental Validity of School Grit and School Self-control for Explaining Mathematics Grades

Due to the variability in the assessment criteria between subjects and year groups, it was not possible to obtain a meaningful measure of average academic achievement across all school subjects for all the students in the study. Only mathematics grades were comparable for all the students from both schools. Therefore, the incremental validity of school grit and school self-control for explaining the variance in mathematics grades collected in June 2017 (at the same time as the survey data collection) was examined using hierarchical multiple linear regression.

KS2 mathematics level and quantitative CAT scores accounted for 66% of all variance in June 2017 mathematics grades (see Table 6-9, after controlling for school, gender, year group, SEN, EAL and FSM status). School grit only added 0.5% ($p < .001$) to explaining the variance. The two dimensions of school grit together also accounted for 0.5%, with school self-control accounting for 0.8% additional contribution in explaining the variance in of mathematics grades.

After controlling for mathematics self-efficacy and mathematics mindsets about intelligence (accounting for a further 1%, Model 2 Table 6-10), school grit and school self-control were still statistically significant, although their contribution was now negligible (0.1% and 0.3% respectively). This agreed with the initial hypothesis, that as ***school-specific*** measures of perseverance (rather than mathematics-specific perseverance) the incremental validity of school grit and school self-control for explaining the variance in mathematics grade was going to be low.

Table 6-9 Results of regression analyses: mathematics achievement - June 2017 mathematics grades from both schools

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-4.771	.471		-5.647	.509		-5.644	.509		-5.545	.489	
School 2	.039	.071	.010	.071	.071	.019	.070	.071	.019	.043	.070	.011
Male	-.309	.067	-.082***	-.301	.067	-.080***	-.297	.067	-.079***	-.265	.067	-.070***
Year Group	.061	.040	.026	.074	.040	.032	.074	.040	.032	.066	.040	.029
SEN Status	-.287	.080	-.066***	-.279	.080	-.065***	-.281	.080	-.065***	-.278	.079	-.064***
EAL Status	.349	.116	.055**	.301	.116	.048**	.298	.116	.047*	.303	.115	.048**
FSM Ever6 Status	-.254	.091	-.051**	-.240	.091	-.048**	-.237	.091	-.047**	-.210	.091	-.042*
Y7 Quantitative CAT Score	.026	.004	.193***	.025	.004	.190***	.025	.004	.189***	.026	.004	.191***
KS2 Maths Level	.245	.011	.628***	.244	.011	.626***	.244	.011	.624***	.244	.011	.626***
Grit				.245	.057	.076***						
Grit Consistency of Interest							.093	.047	.036*			
Grit Perseverance of Effort							.153	.048	.059**			
Self-control										.242	.047	.092***
R^2		.661			.667			.667			.669	
Adjusted R^2		.659			.664			.664			.667	
ΔR adj ^2					.005			.005			.008	
F	F(8, 1103)= 269.080***			F(9, 1102)= 245.090***			F(10, 1101)= 220.563***			F(9, 1102)= 247.845***		

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 6-10 Results of regression analyses: mathematics achievement - June 2017 mathematics grades from both schools

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-4.732	.473		-5.177	.476		-5.596	.509		-5.596	.509		-5.601	.489	
School 2	.037	.071	.010	.026	.070	.007	.047	.071	.012	.047	.071	.012	.031	.070	.008
Male	-.315	.068	-.083***	-.341	.068	-.090***	-.334	.068	-.089***	-.334	.068	-.088***	-.308	.068	-.082***
Year Group	.055	.041	.024	.059	.040	.026	.066	.040	.029	.066	.040	.029	.061	.040	.027
SEN Status	-.289	.081	-.066***	-.268	.080	-.061***	-.267	.080	-.061***	-.267	.080	-.061***	-.267	.080	-.061***
EAL Status	.351	.117	.056**	.273	.116	.043*	.256	.116	.041*	.256	.116	.041*	.253	.115	.040*
FSM Ever6 Status	-.271	.092	-.054**	-.261	.091	-.052**	-.256	.091	-.051**	-.255	.090	-.051**	-.233	.090	-.046*
Y7 Quantitative CAT Score	.026	.004	.194***	.024	.004	.179***	.024	.004	.180***	.024	.004	.180***	.024	.004	.181***
KS2 Maths Level	.245	.011	.628***	.240	.011	.613***	.240	.011	.614***	.240	.011	.614***	.240	.011	.614***
Math Self-efficacy				.136	.032	.084***	.119	.033	.073***	.118	.033	.073***	.116	.032	.071***
Math Mindset				.072	.035	.040*	.051	.036	.028	.052	.036	.029	.038	.036	.021
Grit Consistency of Interest							.076	.048	.030						
Grit Perseverance of Effort							.066	.052	.025						
Grit										.142	.062	.044*			
Self-control													.176	.050	.067***
R^2		.662			.672			.673			.673			.675	
Adjusted R^2		.659			.669			.670			.670			.672	
ΔR adj ^2					.010			.001			.001			.003	
F		$F(8,1092)=266.896$***			$F(10,1090)=222.994$***			$F(12,1088)=186.840$***			$F(11,1089)=204.008$***			$F(11,1089)=205.919$***	

*$p < .05$. **$p < .01$. ***$p < .001$.

Similarly, examining the incremental validity of school grit, its two dimensions and self-control showed that these measures did not explain the variance in future mathematics grades nine months after the initial survey (Table 6-11).

Table 6-11 Explaining the variance in future GCSE mathematics grade - April 2018, School 2

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-5.656	.982		-6.016	.957		-6.339	1.011		-6.257	1.008		-6.245	.976	
Male	-.235	.098	-.065*	-.267	.096	-.074**	-.257	.096	-.071**	-.268	.096	-.074**	-.255	.096	-.071**
Year Group	.090	.098	.025	.075	.095	.021	.089	.096	.025	.085	.096	.023	.077	.095	.021
SEN Status	.045	.129	.010	.077	.125	.017	.086	.126	.019	.086	.126	.019	.085	.126	.019
EAL Status	.195	.126	.042	.109	.124	.023	.090	.127	.019	.092	.127	.020	.090	.125	.019
FSM Ever6 Status	-.206	.125	-.046	-.225	.121	-.050	-.215	.122	-.048	-.223	.121	-.050	-.208	.122	-.047
Y7 Quantitative CAT Score	.024	.006	.188***	.022	.005	.171***	.022	.005	.171***	.022	.005	.170***	.022	.005	.171***
KS2 Maths Level	.256	.016	.716***	.250	.015	.699***	.249	.015	.696***	.250	.015	.699***	.251	.015	.701***
Math Self-efficacy				.156	.044	.102***	.140	.046	.091**	.149	.045	.097**	.147	.045	.096**
Math Mindset				.085	.049	.049	.078	.051	.045	.074	.051	.043	.068	.051	.040
Grit Consistency of Interest							-.015	.065	-.006						
Grit Perseverance of Effort							.099	.075	.039						
Grit										.070	.091	.023			
Self-control													.088	.075	.034
R^2		.762			.776			.778			.777			.777	
Adjusted R^2		.757			.770			.770			.770			.771	
ΔR adj ^2					.013			0			0			.001	
F		*F*(7,338)= 154.330***			*F*(9,336)=129.679***			*F*(11,334)= 106.186***			*F*(10,335)=116.629***			*F*(10,335)=116.987***	

$*p < .05$. $**p < .01$. $***p < .001$.

In addition, for each student the difference between their actual achievement (grade in mathematics in April 2018, nine months after the survey) and target grade (based on the targets generated by Family Fischer Trust) was calculated, as an indication of future academic achievement against personal targets (see Tables 6-12 and 6-13). This is a measure commonly used by teachers and schools to track students' progress against their targets, referred to as "value added" (Mortimore, Sammons, & Thomas, 1994). Each student's target grade is generated by the Family Fischer Trust from complex models that account for a variety of student characteristics.

Again, it was found that KS2 mathematics level and quantitative CAT scores (after controlling for gender, year group, SEN, EAL and FSM status) accounted for 4.3% of all variance. When comparing each student's future actual grade against their personal target grade in GCSE mathematics, beyond demographic measures, prior grades and cognitive ability, school grit (5%), *perseverance of effort* dimension (5.5%) and school self-control (2.1%) made a significant contribution in explaining the variance in (see Table 6-12). Interestingly, even after controlling for mathematics self-efficacy and mindset (accounting for 8.9% of all variance, Model 2, Table 6-13), grit *perseverance of effort* dimension continued to make an additional 2.4% significant contribution in explaining the variance in, while the *consistency of interest* dimension of grit and school self-control failed to make a significant contribution. School grit as a composite measure had a lower contribution than its *perseverance of effort* dimension (2.1% versus 2.4%).

Table 6-12 GCSE mathematics grade delta (Actual Future Grade minus Target Grade) – April 2018, School 2

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	2.278	1.100		.690	1.129		.550	1.129		1.561	1.115	
Male	.108	.110	.053	.097	.107	.048	.112	.107	.055	.136	.109	.067
Year Group	-.238	.110	-.118*	-.190	.108	-.094	-.182	.108	-.090	-.237	.109	-.117*
SEN Status	.099	.140	.040	.155	.137	.063	.156	.137	.063	.121	.139	.049
EAL Status	.266	.142	.102	.140	.141	.054	.131	.141	.050	.202	.142	.078
FSM Ever6 Status	.003	.140	.001	.011	.136	.004	.022	.136	.009	.042	.139	.017
Y7 Quantitative CAT Score	-.003	.006	-.036	-.004	.006	-.054	-.004	.006	-.052	-.003	.006	-.042
KS2 Maths Level	-.014	.018	-.070	-.016	.017	-.079	-.018	.017	-.089	-.013	.017	-.066
Grit				.413	.093	.238***						
Grit Consistency of Interest							.121	.070	.093			
Grit Perseverance of Effort							.312	.079	.216***			
Self-control										.230	.079	.157**
R^2		.043			.095			.103			.067	
Adjusted R^2		.024			.074			.079			.045	
ΔR adj ^2					.050			.055			.021	
F		*F* (7,341)= 2.198*			*F* (8, 340)= 4.486***			*F* (9, 339)= 4.311***			*F* (8, 340)= 3.037**	

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 6-13 GCSE mathematics grade delta (Actual Future Grade minus Target Grade) - April 2018, School 2

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	5.459	1.581		4.503	1.559		3.701	1.565		3.653	1.568		4.316	1.560	
Male	.127	.110	.063	.086	.108	.042	.105	.107	.052	.087	.106	.043	.106	.108	.052
Year Group	-.361	.118	-.178**	-.354	.115	-.175**	-.320	.114	-.158**	-.320	.114	-.158**	-.357	.115	-.176**
Maths Band	-.270	.095	-.277**	-.222	.093	-.228*	-.252	.093	-.258**	-.237	.092	-.243*	-.235	.093	-.241*
SEN Status	.069	.144	.027	.105	.140	.041	.142	.139	.055	.142	.139	.056	.116	.140	.045
EAL Status	.248	.141	.095	.161	.139	.062	.082	.140	.031	.086	.140	.033	.131	.140	.050
FSM Ever6 Status	.002	.139	.001	-.019	.136	-.008	.004	.134	.001	-.009	.134	-.004	.006	.136	.002
Y7 Quantitative CAT Score	-.007	.006	-.095	-.008	.006	-.117	-.009	.006	-.124	-.009	.006	-.124	-.008	.006	-.118
KS2 Maths Level	-.048	.021	-.237*	-.048	.021	-.239*	-.053	.021	-.262*	-.049	.021	-.245*	-.048	.021	-.240*
Math Self-efficacy				.169	.049	.196***	.124	.050	.144*	.138	.050	.160**	.156	.050	.180**
Math Mindset				.086	.054	.088	.042	.056	.043	.036	.056	.037	.060	.057	.062
Grit Consistency of Interest							.073	.072	.056						
Grit Perseverance of Effort							.249	.083	.173**						
Grit										.299	.101	.173**			
Self-control													.131	.083	.090
R^2		.063			.115			.144			.138			.122	
Adjusted R^2		.041			.089			.113			.110			.093	
ΔR adj ^2					.048			.024			.021			.004	
F		*F*(8,337)=2.828**			*F*(10,335)=4.368***			*F*(12,333)=4.665***			*F*(11,334)=4.863***			*F*(11,334)=4.213***	

*$p < .05$. **$p < .01$. ***$p < .001$.

6.6 Discussion

The aim of this study was to examine the incremental validity of school grit, its two dimensions and school self-control for explaining the variance in academic achievement as measured by school grades. Moreover, school-specific measures of grit and self-control were used to explain the variance in students' attendance. Beyond demographic measures, prior grades and cognitive ability, school grit, its two dimensions and school self-control made negligible contributions to explaining the variance in of average of the grades across all GCSE subjects. More importantly, after controlling for academic self-efficacy and mindsets about intelligence (accounting for 2.3% of all variance), these constructs no longer made a significant contribution to explaining the variance in average grades. It can, therefore, be argued that academic self-efficacy and mindset about intelligence were the key underlying processes driving academic achievement (as measured by grades), rather than school grit and school self-control.

Furthermore, while school grit, its perseverance of effort dimension and school self-control significantly contributed to explaining the variance in percentage attendance, their contribution was no longer significant after controlling for academic self-efficacy and mindsets. Academic self-efficacy added 1% to explaining the variance in percentage attendance. Using the students' percentage attendance as an outcome variable (as an alternative to average grades) has proven to be useful as a complementary measure that captures academic behaviour.

As hypothesised, the incremental validity of these constructs for explaining the variance in mathematics grades for students in years 7 to 10 from both schools was also negligible. By collecting data on students' GCSE grades nine months after the survey, it was possible to examine the influence of these constructs on future academic achievement. Again, it was found that they made little contribution in explaining the variance. These findings were consistent with previous research which has examined the incremental validity of trait-level grit and self-control for explaining the variance in school grades (Credé et al., 2016; Muenks, Wigfield, et al., 2016; Muenks et al., 2017; West et al., 2014).

Next GCSE mathematics grade delta was calculated by taking away the students' target GCSE mathematics grade from their actual grade, nine months after the survey. Interestingly, even after controlling for mathematics self-efficacy and mindset, grit *perseverance of effort* dimension made an additional 2.4% significant contribution to the explaining the variance, while the *consistency of interest* dimension of school grit and school self-control failed to make a significant contribution in explaining the variance. Moreover, school grit as a composite measure made a lower contribution than its *perseverance of effort* dimension, suggesting that this dimension alone provided greater insights for explaining the students' achievement against their personal targets above and beyond mathematics self-efficacy and mindset.

In sum, it appeared that even as school-specific constructs, school grit, its two dimensions and school self-control made negligible contributions in explaining the variance in school grades and attendance, beyond demographic measures, prior grades and cognitive ability. Moreover, this contribution was no longer significant after controlling for academic self-efficacy and mindset, further highlighting the importance of academic self-efficacy and mindset for academic achievement. However, when explaining the variance in the students' mathematics GCSE grades (9 months after the survey) against personal targets, the *perseverance of effort* dimension of grit continued to make a significant contribution, accounting for 2.4% of all variance, even after controlling for mathematics self-efficacy and mathematical mindset. The *consistency of interest* dimension failed to make a significant contribution in explaining the variance in mathematics achievement in any of the models. This suggests that school grit as a composite measure is not useful for explaining academic achievement, while the *perseverance of effort* dimension items alone can offer insight into students' academic perseverance. This may be due to the fact that the *consistency of interest* dimension used here is school-specific, rather than specific to mathematics and as a result fails to capture the students' interest in mathematics. This agrees with assertion that the *consistency of interest* is more likely to be domain-specific (Cormier et al., 2019; Eskreis-Winkler, 2016; Duckworth & Quinn, 2009). It is worth noting that these self-report items require participants to "integrate behaviour over domains" and, therefore, fail to capture the alignment of the participants' superordinate goal with the domain of the study (Duckworth & Quinn, 2009, p. 173).

Moreover, as discussed in Study 1, adolescents in England can exercise limited choice in their academic subjects and mathematics is a compulsory subject till age 16. This may account for the fact that the school-specific *consistency of interest* dimension fails to make a contribution to explaining the variance. This dimension may be more appropriate for studying students in their post-16 studies once they have made academic choices, pursuing subjects that interest them. Furthermore, findings from Study 1 demonstrated that mathematics-specific measures of self-efficacy outperformed academic-self-efficacy in explaining the variance in mathematics grades. It can, therefore, be expected that using mathematics-specific measures of perseverance will contribute more to explaining the variance in mathematics grades, than the school-specific *perseverance of effort* dimension of grit. Reflecting on these findings suggests that by using measures that capture both dimensions of grit in mathematics, it will be possible to determine whether the contribution to explaining the variance in mathematics grades is currently limited by the fact that these dimensions are school-specific rather than mathematics-specific.

Finally, the findings from this study have since been shared with the schools involved in the research. Additional analysis was also undertaken to address questions raised by the school teams, in order to begin thinking about possible implications for practice in the classroom.

6.6.1 Limitations and Implications for Future research

Whilst 1448 students had completed the survey, due to the variations in grading criteria and availability of the grades, some of the analyses had to be limited to only a subset of this sample. It would, therefore, be worthwhile to extend this study to larger samples from different schools in England.

Moreover, examining the influence of school-specific constructs on future academic achievement assumes the stability of these constructs over time. This assumption needs to be addressed empirically. Whilst the students' grades were collected at two different time points, the students only completed the survey measures once. Using a longitudinal design could have shed greater light on the development of academic perseverance amongst adolescents over time.

Furthermore, it can be suggested that to capture the impact of perseverance constructs for explaining the variance in academic achievement, measures (such as GCSE mathematics delta used here) that capture the students' achievement against their personal targets can prove more useful than just grades. It is this gap between the students' academic grades and their personal targets and, not the grades alone, that can highlight the importance of academic perseverance in adolescents. Finally, using mathematics-specific measures that reflect and capture the two dimensions of grit in mathematics can help develop a clearer picture of perseverance in mathematics and its role in explaining the variance in academic achievement in mathematics. This is the focus of Study 2b.

Despite the strengths of the empirical research design which has informed a greater understanding of the underlying mechanisms for academic perseverance, as this investigation was not experimental, only correlational relationships were observed. Causal inferences are, therefore, not warranted. This, of course, bears significant implications for the design of future studies, since the shortcomings of the cross-sectional design can be overcome by conducting a field experiment. Using an intervention study will enable me to examine the processes at play. In short, the development of an intervention to enhance academic perseverance in Study 3 lies at the heart of my research's *utility*, axiologically, paradigmatically and ethically.

Chapter 7: Study 2b - Perseverance in Mathematics

Self-efficacy theory, as the central theory for this research, emphasises the importance of using domain-specific measures that capture contextual factors in specific school subjects, such as mathematics (Bandura, 1977; Pajares, 1996; Schunk & DiBenedetto, 2016). To this end, as well as using a mathematics-specific measure of self-efficacy, this study aimed to operationalise perseverance using two mathematics-specific measures of perseverance amongst adolescents: effort regulation in mathematics and perceived instrumentality of mathematics. These two constructs capture the two facets of perseverance in mathematics, mirroring the conceptualisation of academic perseverance in the research literature. Drawing on the same sample as Study 2a, the participants in this study were students (*N* = 1448) from two comprehensive schools in England, (*M* age = 14.00 years, *SD* = 1.1).

To determine the suitability and utility of these two constructs for the study of academic perseverance, their incremental validity for explaining the variance in mathematics grades and students' future academic intentions and goals were investigated, using hierarchical multiple linear regression analyses. Moreover, the incremental validity of effort regulation in mathematics and perceived instrumentality of mathematics were compared with school-specific measures of academic perseverance – school grit and school self-control. The findings from this study are discussed in light of the research literature and their implications for future research and practice are then addressed.

7.1 Background and Rationale

Consistent with previous research, Studies 1 and 2a demonstrated that trait-level and school-specific grit and self-control hade very low incremental validity for explaining the variance in academic achievement (grades) and academic behaviours such as school attendance, after controlling for the students' demographic characteristics, prior attainment and cognitive ability. Thus, it was proposed to investigate whether the low inctremental validity observed was due to the low specificity of the measures to the context due to issues with construct validity for the school-specific measures of grit and self-control. The theoretical framework for this research (see Chapter 3) suggests that domain-specific measures of academic perseverance are likely to be superior to trait-level or even school-specific constructs, since they better capture the complexities and the interactions between adolescent students and their academic contexts (Pajares & Schunk, 2001; Bandura, 1997; Pajares, 1996). Therefore, using effort regulation in mathematics and the perceived instrumentality of mathematics as mathematics-specific measures of perseverance is likely to improve the explanation of the variance in of mathematics grades and students' future academic goals.

As previously discussed, grit as a construct aims to capture two facets of academic perseverance – the learners' daily regulation of effort in academic tasks such as being attentive in lessons and completing homework, as well as maintaining their interest over the long run, resulting in academic/ career goals such as higher education course enrolment and retention. However, as found in Studies 1 and 2a and demonstrated in previous research (Credé et al., 2016; Muenks et al., 2017; Steinmayr et al., 2018), only the *perseverance of effort* dimension of grit makes a significant, be it small, contribution in explaining the variance in academic achievement, with the *consistency of interest* failing to make a significant contribution. This suggests that using a composite measure such as the grit scale masks the underlying mechanisms of academic perseverance and results in drawing inaccurate conclusions about the processes at play. Therefore, it is important to identify domain-specific conceptions of academic perseverance that represent each of these separate facets of perseverance in mathematics amongst adolescents. In the sections that follow, the two constructs of effort regulation in mathematics and perceived instrumentality of mathematics, their construct validity, internal consistency and incremental validity for explaining the variance in mathematics grades and future academic goals are examined.

7.2 Perseverance in Mathematics amongst Adolescents

The next two sections outline the research literature on effort regulation and perceived instrumentality to establish their construct validity for capturing the two facets of perseverance in mathematics.

7.2.1 Effort Regulation

Effort regulation in academic settings can be defined as the management of effort in learning activities in the face of difficulties (Kim, Park, Cozart, & Lee, 2015). From the social cognitive theory perspective, Pintrich and colleagues (1993) view effort regulation as a facet of self-regulation that signifies the students' ability to sustain effort and attention on academic tasks, even after they feel bored or in the presence of environmental distractions. Effort regulation, as a subset of self-regulation, is also concerned with "maintaining the volition for learning until the learning goal is achieved", especially when facing distractions such as fatigue, boredom, and mundane tasks (Onoda, 2014, p. 360). This is well-aligned with the conception of academic perseverance in adolescents in the research literature. More importantly, it has been found that the effort regulation subscale (Pintrich, et al., 1991, 1993) successfully "assesses one's aptitude for regulating attention and effort regardless of distractions and level of interest" (Dunn, Lo, Mulvenon, & Sutcliffe, 2012, p. 313). It, therefore, appears that the effort regulation items are more reflective of learners' daily academic experiences of distractions and boredom, and represent the learners' need for perseverance in a context or given school subject (Dunn, Lo, Mulvenon, & Sutcliffe, 2012) than the *perseverance of effort* items of the grit scale (GRIT-S; see Appendix B for items).

Pintrich and de Groot (1990) found that effort regulation was positively correlated with adolescents' academic self-efficacy, strategy use and academic achievement. They attribute this to the fact that learners with high self-efficacy are likely to anticipate success, opt for challenging tasks, and maintain and regulate their effort for learning through strategy use, resulting in positive academic outcomes (Schunk & Zimmerman, 2012; Zimmerman & Cleary, 2006; Zimmerman, 2000; Pintrich, 1999). The importance of effort regulation for academic achievement is supported by prior research examining its underlying mechanisms (Komarraju & Nadler, 2013; Robbins, Allen, Casillas, Peterson, & Le, 2006). In fact, it has been shown that self-efficacy is critical for facilitating academic effort regulation and enabling students to maintain their focus on academic tasks (Komarraju & Nadler, 2013; Robbins et al., 2006). Moreover, the learner's fixed or growth mindset about intelligence can influence effort regulation as these conceptions reflect the learner's beliefs about the relationship between effort expenditure and ability in specific academic contexts or subjects (Dweck & Sorich, 1999).

Conceptually, there are considerable similarities between effort regulation and the *perseverance of effort* dimension of grit. Muenks and colleagues' (2017) factor analytic examination of grit and its two dimensions showed that the *perseverance of effort* subscale items in the Grit-S were "almost identical" to items on the effort regulation measure (Pintrich & De Groot, 1990), and that "these items factored together in exploratory factor analyses, rendering them empirically indistinguishable" (Muenks et al., 2017, p. 3).

However, it is worth highlighting a key difference between the two measures: the *perseverance of effort* items are not specific to a given domain or school subject while the effort regulation items are sensitive to context and require the student to think of a given school subject when responding.

Given the alignment of effort regulation with the theoretical framework of this research, the close conceptual and empirical overlap between effort regulation and the *perseverance of effort* dimension of grit, the accuracy of the effort regulation items in capturing its conceptualisation and perhaps most significantly the level of specificity of effort regulation to a school subject, it was decided to use effort regulation in mathematics to conceptualise and operationalise perseverance of effort in mathematics.

7.2.2 Perceived Instrumentality

Perceived Instrumentality is defined as the extent to which learners perceive performing in the current task as instrumental to achieving personally valued future goals (Husman, Derryberry, Crowson, & Lomax, 2004; Husman & Lens, 1999; Miller, Behrens, Greene, & Newman, 1993; Miller & Brickman, 2004). Husman and Lens (1999) found that learners with higher perceived instrumentality were more motivated, self-regulated, and achieved higher grades than those with lower instrumentality.

Miller and Brickman (2004) put forth a model, arising from their synthesis of social cognitive theory and future-oriented motivation. They posit that personally valued goals help individuals develop a system of sub-goals that enable the individual to achieve their superordinate goal. By clarifying and elaborating their sub-goals, individuals become aware of the choices presented to them in their immediate environment. This facilitates them in focusing on sub-goals that are aligned with their personally valued future goals. Miller and

Brickman (2004) suggest that perceived instrumentality of current tasks has two key benefits for academic achievement: firstly, it conveys the incentives of the current tasks for achieving the future goals and secondly, it impacts the achievement of the superordinate goal. Perceived instrumentality closely reflects the conceptualisation of grit and the alignment of sub-goals with the superordinate goal with a long-term timescale (especially the *consistency of interest* dimension). However, its operationalisation has the advantage of accurately capturing the long-term quality of the learner's superordinate goal in a given academic context or school subject, something that the *consistency of interest* items fail to do (as discussed in Chapter 2). Miller and Brickman's perceived instrumentality scale is a measure of a learner's perception of the extent to which class performance or academic achievement in a given school subject is "a step along a path to a valued future goal" (Miller & Brickman, 2004, p. 18). This scale is consistent with the theoretical perspective that personally valued superordinate goals enhance the incentives of immediate tasks if these tasks are seen as instrumental to the attainment of the superordinate goals (Miller & Brickman, 2004).

High perceived instrumentality demonstrates a clear understanding of how a learner's current activities can help achieve future goals. Therefore, one can conclude that for a learner to be high in perceived instrumentality in a school subject such as mathematics, the learner needs to maintain effort and interest for their long-term goals, or in other words be gritty (Muenks et al., 2017). Yet, Muenks and colleagues (2017) found that exploratory factor analyses revealed that grit and its two dimensions were empirically distinct from, and relatively weakly related to instrumentality. This further supports findings from previous research which highlighted the divergence of grit's conceptualisation from its operationalisation in capturing consistency of interest (Credé et al., 2016; Muenks et al., 2017; Steinmayr et al., 2018). To overcome this shortcoming, it was, therefore, decided to use perceived instrumentality to conceptualise and operationalise consistency of interest in mathematics in adolescents.

7.3 Research Questions and Hypotheses

The key research questions addressed in this study were:

RQ1: To what extent do effort regulation in mathematics and the perceived instrumentality of mathematics, as measures of perseverance in mathematics, explain the variance in mathematics achievement amongst adolescents?

RQ2: To what extent do these measures of perseverance in mathematics outperform the incremental validity of school grit, its two dimensions and self-control in their explanation of the variance in mathematics grades?

RQ3: To what extent do these measures of perseverance in mathematics explain the variance in the students' future academic intentions and goals in mathematics?

In light of the theoretical framework for this research, it was hypothesised that measures of perseverance in mathematics would surpass the incremental validity of school grit, its two dimensions and school self-control for explaining the variance in both academic achievement (as measured by grades) and the students' future academic intentions and goals in mathematics. Based on the findings from previous research and Studies 1 and 2a, it was further hypothesised that effort regulation in mathematics would explain the variance in mathematics grades, whereas perceived instrumentality would explain the variance in the students' future academic intentions and goals in mathematics.

7.4 Analytic Plan

In this study, the incremental validity of two mathematics-specific measures of perseverance in mathematics, namely effort regulation in mathematics and perceived instrumentality of mathematics were examined, using hierarchical multiple linear regression by focusing on explaining the variance in:

1. Mathematics grades for all year groups from both schools
2. GCSE mathematics future grades for students in years 10 and 11 (9 months after the survey)
3. Actual GCSE mathematics grades against personal target grades for students in years 10 and 11 (9 months after the survey)
4. Students' declared intentions and goals for the future as related to mathematics

Specifically, it was hypothesised that effort regulation in mathematics would have higher incremental validity for explaining the variance in academic achievement as measured by mathematics grades (see 1, 2 and 3 above) compared with school grit's *perseverance of effort* dimension, while perceived instrumentality of mathematics would have higher incremental validity for explaining the variance in the students' declared intentions and goals for the future as related to mathematics, compared with the *consistency of interest* dimension of grit.

7.5 Methods

The data for this study was collected at the same time as Study 2a. The participants in this study were students (*N* = 1448) from two comprehensive schools in England, (*M* age = 14.00 years, *SD* = 1.1). For details of participants and procedures, see sections 6.3.1. Please note that from here on effort regulation in mathematics will be referred to as mathematics effort regulation and perceived instrumentality of mathematics will be referred to as mathematics instrumentality.

7.5.1 Measures

Demographics, Academic Attainment and Cognitive Ability

Participants were asked to report their date of birth and gender. The schools provided other demographic data on the students' Special Educational Needs (SEN), English as an Additional Language (EAL) and Free School Meals Ever (FSM Ever) status at the time of data collection (June 2017). As a measure of prior attainment, the students' Key Stage 2 results were provided for Reading, Writing and Mathematics. Furthermore, the students' quantitative Cognitive Ability Test scores administered in year 7, as a measure of cognitive ability were supplied by the school. Year 7 CAT scores and KS2 results were not available for all students. In April 2018, one of the schools was able to provide students' mathematics grade and personal target grades from their GCSE mathematics classes, for students in years 10 and 11.

7.5.2 Mathematics Self-report Measures

Effort-regulation in Mathematics

The effort regulation scale from the MSLQ (Pintrich et al., 1991) was used to measure effort regulation in mathematics. The scale consists of four items (e.g., "I work hard to do well in maths even if I don't like what we are doing"). Students responded on a scale from 1 = not at all true of me to 7 = very true of me. When responding to the items, participants were asked to think about their current mathematics lessons (α = .72).

Perceived Instrumentality of Mathematics

Perceived instrumentality of mathematics (Miller, DeBacker, & Greene, 1999) was measured using 5-items (e.g., "I do my maths work because getting a good maths grade helps me achieve my future goals"), on a 5-point scale from 1 = strongly disagree to 5 = strongly agree, with a high score indicating high mathematics instrumentality ($\alpha = .92$).

Mathematics Self-efficacy

Mathematics self-efficacy was assessed using the average score of two items written in accordance with recommendations by Bandura (2006; e.g., "I am confident that I can figure out even the hardest concepts in my maths lessons" and "I am confident that I can understand the material in my maths lesson") on a 6-point scale from strongly disagree to strongly agree with a high score indicating high self-efficacy in mathematics ($\alpha = .80$). Furthermore, sources of self-efficacy in mathematics was assessed using a 24-item instrument (Usher & Pajares, 2009; see Appendix B.7 for items).

Mathematical Mindset

The 2-item mindset self-report scale (Farrington, Levenstein, & Nagaoka, 2013) was used to determine a learner's mathematical mindset with participants rating their mindset in mathematics on a 5-point scale (1 = not at all true to 5 = completely true). A high score indicated a growth mindset, whereas a low score indicated a fixed mindset in mathematics ($\alpha = .68$).

Maths Goal

The students were asked to report their intention to: continue studying mathematics beyond GCSEs, beyond school, as well as their intention to take a job/ pursue a career that required good mathematical skills. This was coded as 0 (no intention), 1, 2 or 3 depending the number of positive answers to the above questions. This variable was termed Maths Goal, in an attempt to measure students' future goals and intentions with regards to mathematics.

7.6 Results and Findings

7.6.1 Descriptive Statistics and Zero-order Correlations for Mathematical Perseverance Measures

As expected, mathematics effort regulation and mathematics instrumentality were correlated with mathematics self-efficacy and mathematical mindset (see Table 7-1). Moreover, these correlations were similar to the correlations observed between school grit/ school self-control and the generalised measures of academic self-efficacy and mindset about intelligence, as in Study 2a (see Table 6-2).

Table 7-1 Means, standard deviations, and bivariate zero-order correlations for major mathematical variables

	1	2	3	4	5	6	7	α
1. Math Effort Regulation	-							.723
2. Math Instrumentality	.417**	-						.918
3. Math Self-efficacy	.544**	.405**	-					.800
4. Math Mindset	.382**	.298**	.396**	-				.679
5. Maths Goal	.261**	.452**	.311**	.207**	-			
6. Year 7 Quantitative CAT Score	.177**	.107**	.248**	.203**	.192**	-		
7. KS2 Maths Level	.115**	.064*	.253**	.191**	.188**	.771**	-	
N	1435	1440	1435	1448	1448	1381	1145	
M	4.69	3.48	3.97	3.91	1.60	104.57	13.99	
SD	1.25	.98	1.17	1.04	1.39	30.19	4.87	

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

7.7 Evaluating Mathematics Effort Regulation and Instrumentality as Measures of Perseverance in Mathematics

7.7.1 Psychometric Properties

Exploratory factor analysis showed two clear factors with the correct items loading onto each construct: mathematics effort regulation and mathematics instrumentality. The nine items (four items of effort regulation scale and five items of mathematics instrumentality scale) were subjected to principal components analysis (PCA) using SPSS version 24. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = .861) exceeded the recommended value of .6 and the Bartlett's Test of Sphericity value was significant ($p < .001$), supporting the factorability of the correlation matrix (Pallant, 2013a).

As expected, PCA revealed the presence of two components with eigenvalues exceeding 1, explaining a total of 66.4% variance, with mathematics instrumentality items explaining 49.1% and effort regulation items explaining 17.3% of the variance. Oblimin rotation was performed to interpret the two components, with both components showing a number of strong loadings and all variables loading substantially on only one component. This was consistent with the two distinct and defined constructs of mathematics effort regulation and mathematics instrumentality (see Table 7-2).

Table 7-2 Pattern matrix for PCA with direct Oblimin rotation with Kaiser normalisation

Item	Pattern coefficients		Communalities
	Ma Instrumentality	Ma Effort Regulation	
EfReg1	.046	**.684**	.496
EfReg2	.017	**.731**	.545
EfReg3	-.008	**.719**	.511
EfReg4	-.047	**.821**	.645
MaInst1	**.794**	.054	.669
MaInst2	**.888**	-.035	.764
MaInst3	**.828**	.049	.722
MaInst4	**.925**	-.045	.824
MaInst5	**.897**	-.009	.799

7.7.2 External Criteria

The correlations of mathematics effort regulation and mathematics instrumentality with school grit and school self-control as generalised measures of perseverance in school were also examined (see Table 7-3). As expected, mathematics effort regulation and instrumentality were positively correlated with school grit and school self-control, as well as with Maths Goal (as a proposed measure of students' long-term academic and career goals related to mathematics). Mathematics instrumentality was correlated with Maths Goal (r = .45). The low correlation coefficients of the *consistency of interest* dimension of grit with both mathematics instrumentality (r = .15) and Maths Goal (r = .04) highlighted the failure of grit's *consistency of interest* items in capturing the students' long-term goals in a given subject, namely mathematics, and further demonstrated the need for a subject-specific measure.

Table 7-3 Bivariate zero-order correlations for perseverance variables

	1a	1b	2	2a	2b	3	4	α
1a. Ma Instrumentality	-							.918
1b. Ma Effort Regulation	.417**	-						.723
2. School Grit	.277**	.543**	-					.687
2a.Consistency of Interest	.148**	.351**	.815**	-				.558
2b.Perseverance of Effort	.302**	.531**	.805**	.311**	-			.718
3. School Self-control	.283**	.515**	.615**	.459**	.539**	-		.818
4. Ma Goal	.452**	.261**	.128**	0.043	.166**	.080**	-	-

** Correlation is significant at the 0.01 level (2-tailed).

7.7.3 The Incremental Validity of Mathematics Effort Regulation and Mathematics Instrumentality

In order to examine mathematics effort regulation and mathematics instrumentality, as measures of perseverance in mathematics, their incremental validity for explaining the variance in mathematics grades and the students' Maths Goal were examined. Preliminary analyses were conducted to ensure no violation of the assumptions of regression, namely independence of errors, multicollinearity, influential cases in the model and homoscedasticity of residuals.

Explaining the Variance in Mathematics Grade across Years 7, 8, 9 and 10

Using hierarchical multiple linear regression, it was found that demographic characteristics of school, gender, year group, Special Educational Needs, English as an Additional Language and Free School Meals Ever status accounted for 13.6% of all variance in mathematics grade. Beyond demographic characteristics, the students' Key Stage 2 maths level, and Year 7 quantitative CAT score added 52.5% to the explanation of the variance in mathematics grade (Model 1, (Table 7-4), accounting for a total of 66% of all variance in mathematics grades. Mathematics effort regulation was entered in block 2, accounting for an additional 0.4% of variance in mathematics grade (Model 2). This meant that above and beyond demographic characteristics, cognitive ability and prior attainment, mathematics effort regulation was still making a contribution (be it a small one) in explaining the variance in mathematics grade. This was particularly important, since in Study 1 trait-level grit failed to contribute to explaining the variance in of average GCSE point scores. It is also worth noting that the addition of school-specific *perseverance of effort* dimension of grit in block 3 added a further 0.1%, statistically significant contribution explaining the variance.

Table 7-4 Results of regression analyses: mathematics grade - June 2017, both schools

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-4.700	.474		-5.209	.488		-5.430	.499	
School 2	.040	.071	.011	.042	.071	.011	.053	.071	.014
Male	-.316	.068	-.084***	-.318	.067	-.085***	-.307	.067	-.082***
Year Group	.054	.041	.023	.070	.041	.030	.072	.041	.031
SEN Status	-.291	.081	-.067***	-.287	.081	-.066***	-.287	.080	-.066***
EAL Status	.347	.117	.055**	.314	.116	.050**	.298	.116	.048*
FSM Ever6 Status	-.274	.092	-.055**	-.257	.091	-.051**	-.251	.091	-.050**
Y7 Quantitative CAT Score	.026	.004	.196***	.025	.004	.184***	.025	.004	.185***
KS2 Maths Level	.244	.011	.624***	.245	.011	.626***	.243	.011	.621***
Ma Effort Regulation				.111	.028	.072***	.076	.032	.050*
Grit Perseverance of Effort							.110	.055	.042*
R^2		.660			.665			.666	
Adjusted R^2		.658			.662			.663	
ΔR					.004			.001	
F		F(8, 1091) = 264.758***			F(9, 1090) = 240.393***			F(10, 1089) = 217.363***	

$*p < .05$. $**p < .01$. $***p < .001$.

Explaining the Variance in Future Mathematics GCSE Grade

In April 2018 (nine months after the initial survey), one school provided the students' mathematics GCSE target grade, as well as the students' actual mathematics GCSE grade, for all the students in years 10 and 11. Further analyses were undertaken to examine the incremental validity of mathematics effort regulation in accounting for the variance in future mathematics GCSE grade.

Using hierarchical multiple linear regression, gender, year group, Special Educational Needs, English as an Additional Language and Free School Meals Ever status, the students' Key Stage 2 maths level, and Year 7 quantitative CAT score were entered in block 1, accounting for 76.2% of all variance in future mathematics GCSE grades (see Model 1, Table 7-5). In Model 2, mathematics effort regulation contributed an additional 1.6% to explaining the variance. School-specific *perseverance of effort* dimension of grit failed to add to the explanation of the variance (Model 3).

Table 7-5 Results of regression analyses: future mathematics GCSE grade - April 2018, School 2

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	-5.656	.982		-5.209	.488		-5.430	.499	
Male	-.235	.098	-.065*	-.318	.067	-.085***	-.307	.067	-.082***
Year Group	.090	.098	.025	.070	.041	.030	.072	.041	.031
SEN Status	.045	.129	.010	-.287	.081	-.066***	-.287	.080	-.066***
EAL Status	.195	.126	.042	.314	.116	.050**	.298	.116	.048*
FSM Ever6 Status	-.206	.125	-.046	-.257	.091	-.051**	-.251	.091	-.050**
Y7 Quantitative CAT Score	.024	.006	.188***	.025	.004	.184***	.025	.004	.185***
KS2 Maths Level	.256	.016	.716***	.245	.011	.626***	.243	.011	.621***
Ma Effort Regulation				.111	.028	.072***	.076	.032	.050*
Grit Perseverance of Effort							.110	.055	.042*
R^2		.762			.777			.778	
Adjusted R^2		.757			.772			.772	
ΔR					.015			.000	
F		*F* (7, 338) = 154.330***			*F* (8, 337) = 147.194***			*F* (9, 336) = 130.572***	

*$p < .05$. **$p < .01$. ***$p < .001$.

Since mathematics effort regulation had made a modest statistically significant contribution in explaining the variance in future mathematics GCSE grade, regression models were built to compare this contribution to the incremental validity of self-efficacy in mathematics and mathematical mindset (1.3%, see Table 7-6, Model 2). Even after controlling for self-efficacy in mathematics and mathematical mindset, mathematics effort regulation still added 0.5% (Model 3). Interestingly, after adding mathematics effort regulation to Model 3, self-efficacy in mathematics and mathematical mindset no longer made a statistically significant contribution to explaining the variance in of future mathematics grades. This may point to the underlying mechanisms of effort regulation in mathematics, requiring further investigation (see Study 2c).

Table 7-6 Explaining the variance in future mathematics GCSE grade - April 2018, School 2

	Model 1			Model 2			Model 3		
Variable	B	SE	β	B	SE	β	B	SE	β
Intercept	-5.656	.982		-6.016	.957		-6.562	.969	
Male	-.235	.098	-.065*	-.267	.096	-.074**	-.248	.095	-.069**
Year Group	.090	.098	.025	.075	.095	.021	.097	.095	.027
SEN Status	.045	.129	.010	.077	.125	.017	.111	.125	.024
EAL Status	.195	.126	.042	.109	.124	.023	.108	.123	.023
FSM Ever6 Status	-.206	.125	-.046	-.225	.121	-.050	-.191	.121	-.043
Quantitative CAT Score	.024	.006	.188***	.022	.005	.171***	.022	.005	.169***
KS2 Maths Fine Grade	.256	.016	.716***	.250	.015	.699***	.254	.015	.709***
Math Self-efficacy				.156	.044	.102***	.092	.049	.060
Math Mindset				.085	.049	.049	.059	.049	.034
Math Effort Regulation							.127	.046	.086**
R^2		.762			.776			.781	
Adjusted R^2		.757			.770			.775	
ΔR adj ^2					.013			.005	
F		*F* (7,338)= 154.330***			*F* (9,336)=129.679***			*F* (10,335)= 119.740***	

*$p < .05$. **$p < .01$. ***$p < .001$.

Explaining the Variance in Future Mathematics GCSE Grade Delta (Actual Future Grade minus Target Grade)

To gain a more accurate picture of a student's future performance in mathematics against their personal target grades, nine months after initial data collection the gap between a student's actual grade in April 2018 (as a measure of actual achievement in mathematics) and personal target grade (based on updated data provided by the Family Fischer Trust) was calculated. This is a measure commonly used by teachers and schools to track students' progress against their targets, referred to as "value added" (Mortimore et al., 1994). Each student's target grade is generated by the Family Fischer Trust from complex models accounting for a variety of student characteristics.

The results of regression analyses indicated that mathematics effort regulation explained 7.6% of all variance in future mathematics GCSE grade delta (actual future grade – target grade), above and beyond demographic characteristics, measures of prior attainment and cognitive ability (see Model 2, Table 7-7). School-specific *perseverance of effort* dimension of grit only added 0.6% to explaining the variance (Model 3). This analyses further suggests that effort regulation in mathematics is the primary variable explaining the variance in future academic achievement in mathematics, in particular against students' personal targets.

Table 7-7 Explaining the variance in GCSE mathematics grade delta (Actual Future Grade minus Target Grade) – April 2018, School 2

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	2.211	1.105		.955	1.086		.519	1.107	
Male	.095	.110	.047	.105	.106	.052	.113	.106	.056
Year Group	-.234	.111	-.116*	-.203	.106	-.101	-.186	.106	-.092
SEN Status	.074	.145	.029	.159	.140	.062	.166	.140	.065
EAL Status	.275	.142	.106	.211	.137	.081	.170	.138	.065
FSM Ever6 Status	-.004	.141	-.002	.044	.135	.018	.047	.135	.019
Y7 Quantitative CAT Score	-.003	.006	-.036	-.004	.006	-.063	-.004	.006	-.062
KS2 Maths Level	-.013	.018	-.063	-.010	.017	-.051	-.013	.017	-.065
Ma Effort Regulation				.234	.043	.284***	.186	.050	.226***
Grit Perseverance of Effort							.167	.089	.116
R^2		.040			.118			.127	
Adjusted R^2		.021			.097			.103	
ΔR					.076			.006	
F		*F* (7, 338) = 2.034*			*F* (8, 337) = 5.620***			*F* (9, 336) = 5.425***	

*p < .05. **p < .01. ***p < .001.

To further examine other potential variables that may explain the variance in academic achievement against personal targets in mathematics, it was decided to also examine the influence of students' maths band. In England, the students are grouped and taught according to "ability" (although the grouping criteria is greatly disputed, and the grouping is more likely to reflect attainment rather than ability; Boaler, Wiliam, & Brown, 2000; Francis, Archer, et al., 2017; Francis, Connolly, et al., 2017). Generally speaking, the students in bands 1 and 2 are expected to achieve the highest grades (grade 5 and above, similar to the C grade that is necessary for many post-16 opportunities), students in band 3 are those on the borderline, likely to achieve grades 4 and 5. Finally, those in band 4 are the lowest achievers, likely to achieve the lowest grades in mathematics[1]. Therefore, to capture the

[1] As previously mentioned, in the new grading system, 9 is the highest possible grade while 1 is the lowest possible grade.

potential influence of students' ability grouping in mathematics on maths delta, maths band was entered in the regression model. As can be seen in Table 7-8, demographic characteristics, maths band, prior academic attainment and quantitative cognitive ability accounted only for 6.3% of all variance in the students' future GCSE mathematics grade against targets, with the addition of maths band to the model improving the explanation of the variance by 2.3% (comparing Models 1 in Tables 7-7 and 7-8). Addition of mathematics self-efficacy and mindset in Model 2 (Table 7-8) nearly doubled the explanation of the variance, with only mathematics self-efficacy making a statistically significant contribution. In Model 3, the addition of effort regulation in mathematics added a further 2.9% to the explanation of the variance. Mathematics self-efficacy and mindset no longer made a statistically significant contribution to the model, after effort regulation was added in model 3. This model accounted for 14.6% of all variance. It is worth noting that students' maths band was a significant variable in all three models.

Table 7-8 Explaining the variance in future Mathematics GCSE grade delta (Actual Grade minus Target Grade) – April 2018, School 2

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	5.459	1.581		4.503	1.559		3.836	1.547	
Male	.127	.110	.063	.086	.108	.042	.114	.106	.056
Year Group	-.361	.118	-.178**	-.354	.115	-.175**	-.326	.114	-.161**
Maths Band	-.270	.095	-.277**	-.222	.093	-.228*	-.230	.092	-.236*
SEN Status	.069	.144	.027	.105	.140	.041	.151	.139	.059
EAL Status	.248	.141	.095	.161	.139	.062	.160	.137	.061
FSM Ever6 Status	.002	.139	.001	-.019	.136	-.008	.028	.134	.011
Quantitative CAT Score	-.007	.006	-.095	-.008	.006	-.117	-.009	.006	-.123
KS2 Maths Fine Grade	-.048	.021	-.237*	-.048	.021	-.239*	-.044	.020	-.218*
Math Self-efficacy				.169	.049	.196***	.079	.055	.092
Math Mindset				.086	.054	.088	.049	.055	.050
Math Effort Regulation							.176	.051	.214***
R^2		.063			.115			.146	
Adjusted R^2		.041			.089			.118	
ΔR adj ^2					.048			.029	
F		*F* (8,337)= 2.828**			*F* (10,335)=4.368***			*F* (11,334)= 5.180***	

*$p < .05$. **$p < .01$. ***$p < .001$.

7.7.4 Explaining the Variance in Students' Maths Goal

As discussed in Study 2a, in the June 2017 survey, the students were asked to report their intention to continue studying mathematics beyond GCSEs, beyond school and their intention to take on a job or pursue a career that required good mathematical skills. This was coded as 0 (no intention), 1, 2 or 3 depending the number of positive answers to the above questions. This variable was termed Maths Goal, in an attempt to measure students' future goals and intentions with regards to mathematics. 7.7% of all variance in the students' Maths Goal was due to demographic characteristics, the quantitative CAT score and KS2 mathematics level (Model 1, Table 7-9). Mathematics instrumentality added a substantial 16.4% in explaining the variance in the students' Maths Goal, explaining a total of 24.1% of all variance (Model 2, Table 7-9), while school grit's *consistency of interest* dimension failed to make a significant contribution to explaining the variance (Model 3).

Table 7-9 Explaining the variance in students' Maths Goal

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	.294	.576		-2.199	.547		-2.001	.572	
School 2	-.189	.087	-.067*	-.194	.079	-.069*	-.204	.080	-.073*
Male	.366	.083	.130***	.316	.075	.112***	.317	.075	.113***
Year Group	-.096	.050	-.056	-.009	.045	-.005	-.011	.045	-.006
SEN Status	-.070	.097	-.022	-.028	.088	-.009	-.033	.088	-.010
EAL Status	.546	.143	.116***	.281	.131	.060*	.287	.131	.061*
FSM Ever6 Status	.220	.112	.059*	.225	.102	.060*	.225	.102	.060*
Y7 Quantitative CAT Score	.004	.005	.043	.002	.004	.017	.002	.004	.017
KS2 Maths Level	.048	.014	.167***	.047	.012	.164***	.047	.012	.162***
Ma Instumentality				.596	.039	.414***	.602	.039	.418***
Grit Consistency of Interest							-.059	.051	-.031
R^2		.077			.241			.242	
Adjusted R^2		.071			.235			.235	
ΔR					.164			0	
F		$F(8, 1102) = 11.539$***			$F(9, 1101) = 38.937$***			$F(10, 1100) = 35.190$***	

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Moreover, regression models were built to compare the contribution of mathematics instrumentality with the incremental validity of mathematics self-efficacy and mathematical mindset (14.4%, see Table 7-10, Model 2). Even after controlling for self-efficacy in mathematics and mathematical mindset, mathematics instrumentality still added 10.7% to the explanation of the variance in the students' Maths Goal, accounting for a total of 25.9% of all variance.

Table 7-10 Explaining the variance in students' Maths Goal – June 2017, both schools

	Model 1			Model 2			Model 3		
Variable	B	SE	β	B	SE	β	B	SE	β
Intercept	.270	.577		-.629	.565		-2.361	.546	
School 2	-.196	.088	-.070*	-.220	.084	-.078**	-.215	.079	-.077**
Male	.364	.083	.130***	.319	.081	.113***	.300	.075	.107***
Year Group	-.095	.050	-.056	-.089	.048	-.052	-.014	.045	-.008
SEN Status	-.097	.098	-.030	-.042	.094	-.013	-.033	.088	-.010
EAL Status	.552	.143	.118***	.399	.139	.085**	.249	.130	.053
FSM Ever6 Status	.228	.113	.061*	.247	.108	.066*	.242	.101	.065*
Y7 Quantitative CAT Score	.004	.005	.041	.000	.004	.001	.000	.004	.000
KS2 Maths Level	.049	.014	.171***	.038	.013	.130**	.043	.012	.149***
Math Self-efficacy				.257	.038	.213***	.119	.037	.099**
Math Mindset				.164	.041	.122***	.080	.039	.060*
Ma Instrumentality							.524	.042	.365***
R^2		.080			.152			.259	
Adjusted R^2		.073			.144			.252	
ΔR					.071			.108	
F		*F* (8, 1094) = 11.830***			*F* (10, 1092) = 19.558***			*F* (11, 1091) = 34.673***	

*$p < .05$. **$p < .01$. ***$p < .001$.

7.8 Discussion

The aim of this study was to examine effort regulation in mathematics and perceived instrumentality of mathematics as two mathematics-specific facets of academic perseverance amongst adolescents. Comparisons of these two constructs with the two facets of academic perseverance (*perseverance of effort* and *consistency of interest)* demonstrated good construct validity. Both constructs also showed good internal consistency. To further probe into these constructs' psychometric properties, correlations of effort regulation in mathematics and perceived instrumentality of mathematics with school grit, its two dimensions and school self-control, as well as with mathematics self-efficacy and mathematical mindset were examined. As expected, effort regulation in mathematics and perceived instrumentality of mathematics were positively correlated to school grit, its two dimensions and school self-control (see Tables 7-1 and 7-4). This was in line with previous research, demonstrating similar patterns of correlations as those observed for school-specific constructs of grit and self-control with self-efficacy and mindset (Muenks, Wigfield, et al., 2016; Muenks et al., 2017).

Furthermore, hierarchical regression analyses were undertaken to examine the incremental validity of effort regulation in mathematics and perceived instrumentality of mathematics as two mathematics-specific measures of perseverance for explaining the variance in grades in mathematics and the students' future mathematics-related goals. Exploratory factor analysis showed that these two constructs were empirically distinct from each other and were, therefore, treated as separate outcome variables in the regression analyses. The findings showed that effort regulation in mathematics made a significant contribution in explaining the variance in mathematics grade, future mathematics GCSE grade and the students' future performance against their personal targets in GCSE mathematics courses (future mathematics GCSE grade delta), above and beyond demographic characteristics, cognitive ability and prior attainment. This contribution held even after controlling for mathematics self-efficacy and mathematical mindset. Moreover, after entering effort regulation in the model, mathematics self-efficacy and mindset no longer made a significant contribution to explaining the variance in grades.

In explaining the variance in the future mathematics GCSE grade delta (actual future grade minus target grade), other significant variables in the model were year group, maths band, and KS2 mathematics level. These findings suggest that the higher the year group the poorer the performance against target. Year 11 students have studied more challenging materials than those in year 10 and are therefore more likely to fall short of their target and achieve lower grades. As expected, the higher the students' ability band (i.e. the lower the number for maths band), the better the students' achievement against targets. In other words, the higher achieving students were more likely to achieve their personal targets. Moreover, the higher the KS2 mathematics grade, the poorer the achievement against targets. This may initially seem counterintuitive. However, since targets were based on KS2 levels, those with higher KS2 levels would have had higher and more challenging targets.

Mathematics instrumentality made a significant contribution in explaining the variance in of students' Maths Goal, above and beyond demographic characteristics, prior mathematics attainment and cognitive ability. This contribution held even after controlling for mathematics self-efficacy and mathematical mindset. As hypothesised, effort regulation in mathematics was the key variable explaining the variance in mathematics achievement as measured by mathematics grades, while mathematics instrumentality was the key variable explaining the variance in students' intentions and goals for pursuing mathematics and mathematics related pursuits post-16. This provides further evidence against using a composite measure such as grit, highlighting that use of such measures can mask the incremental validity of the dimensions. These findings are well-aligned with the initial hypotheses and provide new evidence in support of prior research (Cormier et al., 2019; Steinmayr et al., 2018; Muenks et al., 2017; Muenks, Wigfield, et al., 2016). It can, therefore, be concluded that mathematics effort regulation and mathematics instrumentality are conceptually and operationally sound for capturing perseverance in mathematics amongst adolescents.

7.8.1 Limitations and Implications for Future research

Examining the influence of effort regulation and instrumentality on future academic achievement assumes the stability of these constructs over time. This assumption needs to be tested empirically. Further, as in Study 2a, a longitudinal design can provide information on the development of perseverance in mathematics amongst adolescents over time.

This study provides further evidence demonstrating that composite measures such as school grit result in drawing erroneous conclusions about the incremental validity of the different dimensions which in turn hinders efforts to deepen the understanding of academic perseverance in adolescents. It is, therefore, suggested that in future research use of composite measures of perseverance is avoided.

Moreover, it can be suggested that to capture the impact of perseverance constructs for explaining the variance in academic achievement, measures (such as GCSE mathematics delta used here) that capture the students' performance against their personal targets can prove more useful than just grades. This gap between the students' academic grades and their personal targets, and not the grades alone, is far more meaningful and further highlights the importance of academic perseverance in adolescents. To capture consistency of interest in mathematics, it is advisable for future research to use a measure akin to the students' Maths Goals as an alternative to grades as an ecologically valid proxy.

The findings from this study further highlighted that mathematics effort regulation and mathematics instrumentality made contributions to explaining the variance in mathematics grades and the students' future maths goals, beyond mathematics self-efficacy and mathematical mindset. This also supports the hypothesised model put forth in Chapter 3 (see Figure 3-5). However, it is important to gain a better understanding of the underlying mechanisms for effort regulation in mathematics and the perceived instrumentality of mathematics, which is addressed in Study 2c.

Chapter 8: Study 2c - The Underlying Mechanisms of Academic Perseverance in Adolescents

8.1 Background and Rationale

The ultimate goal of this research is to enhance academic perseverance in adolescents. It is, therefore, important to identify the underlying mechanisms of academic perseverance, especially since empirical research in adolescents is rather limited. Specifically, despite theorising about the effect of academic self-efficacy (Bandura, 1997; Pajares & Schunk, 2001; Eccles & Wigfield, 2002) and mindsets about intelligence (Dweck, Walton, & Cohen, 2014; Galla et al., 2014), research has rarely addressed their role as possible predictors of academic perseverance. Moreover, little analytical attention has been paid to evaluating the extent of their impact on academic perseverance, specifically in mathematics (Roney, Rose, & McKeown, in press). In this study, the role of mathematics self-efficacy and mathematical mindsets, as predictors of academic perseverance in adolescents, were examined using a large-scale survey (as in Studies 2a and 2b), with four cohorts of students in years 7, 8, 9 and 11 (N = 1448) from two comprehensive schools in England, (M age = 14.00 years, SD = 1.1).

8.2 Aims and Objectives

The aim of this study was to determine the relative contribution of mathematics self-efficacy and mathematical mindsets for predicting mathematics effort regulation and mathematics instrumentality as facets of perseverance in mathematics. The key research question addressed in this study is:

RQ: To what extent do self-efficacy in mathematics and mathematical mindset predict perseverance in mathematics amongst adolescents?

Figure 8-1 shows the hypothesised model of mathematics perseverance, developed in this research based on synthesis of the research literature (see Chapter 3 for the in-depth discussion). This model incorporates the relationship between mathematical mindset and mathematics self-efficacy (Roney, Rose, & McKeown, in press) and is supported by the findings from Studies 1, 2a and 2b in this research programme. Drawing on the theoretical framework for this research, it is hypothesised that self-efficacy in mathematics would make the greatest contribution to predicting perseverance in mathematics amongst adolescents, while mathematical mindsets would make a smaller contribution to this prediction. Moreover, through interpretation of effort and failure (see discussions in Chapter 3), the impact of mathematical mindsets on perseverance in mathematics would likely be mediated through mathematics self-efficacy.

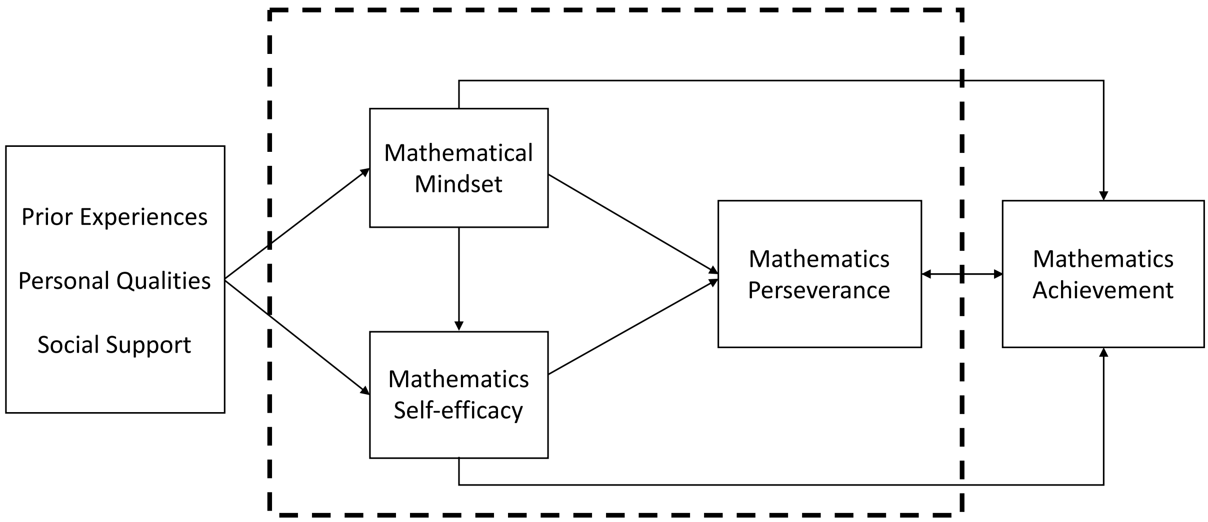

Figure 8-1 Hypothesised model of perseverance in mathematics

8.3 Analytic Plan

In this study, the survey data was used to empirically test the possible mediation model (as shown by the dashed outline in Figure 8-1 and Figure 8-2).

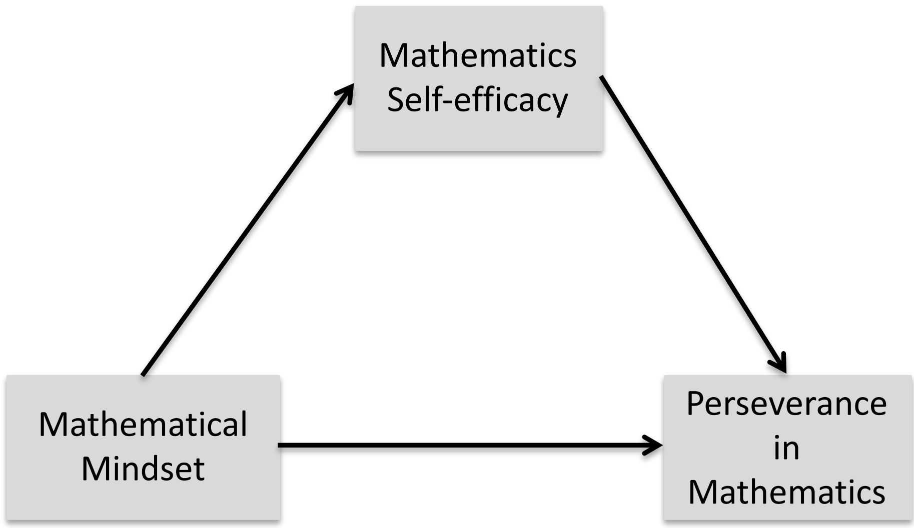

Figure 8-2 Hypothesised mediation model

Using hierarchical multiple regression analyses, the extent of the contribution of mathematics self-efficacy and mathematical mindset for explaining the variance in both facets of perseverance in mathematics were examined. In addition, by focusing on the mediating role of mathematics self-efficacy, the impact of mathematical mindset on perseverance in mathematics was investigated using mediation analyses.

8.3.1 Predicting Perseverance in Mathematics

Findings from Study 2b suggest that mathematics effort regulation and mathematics instrumentality represent two facets of academic perseverance in mathematics amongst adolescents. Therefore, in this study, mathematics effort regulation and mathematics instrumentality were used as measures of academic perseverance in mathematics (see Chapter 7 for discussion). As previously hypothesised, it was expected for mathematics effort regulation and mathematics instrumentality to be associated with mathematics self-efficacy and mathematical mindset.

Predicting Effort Regulation in Mathematics

Preliminary analyses were conducted to ensure no violation of the assumptions of regression namely independence of errors, multicollinearity, influential cases in the model and homoscedasticity of residuals.

Using hierarchical multiple linear regression, demographic characteristics of school, age, gender, Special Educational Needs, English as an Additional Language and Free School Meals Ever status were entered in block 1, accounting for only 2.6% of all variance in mathematics effort regulation (see Model 1 in Table 8-1). In block 2, the students' Key Stage 2 maths level, as a measure of prior mathematics attainment, and Year 7 quantitative CAT score as a measure of cognitive ability, only added 1.8% to the prediction of mathematics effort regulation (Model 2). Mathematics self-efficacy and mathematical mindset were entered in block 3, accounting for an additional 30.2% of the variance in mathematics effort regulation (Model 3). Consistent with the research literature, age at data collection showed a negative association with mathematics effort regulation (Dweck, 2000; Dweck, Walton, & Cohen, 2014; for a review see: Rosenzweig & Wigfield, 2016).

Table 8-1 Results of regression analyses predicting mathematics effort regulation

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	6.973	.598		5.450	.677		3.905	.567	
School 2	-.062	.077	-.025	-.016	.078	-.006	-.063	.064	-.026
Age at Data Collection	-.160	.042	-.115***	-.149	.041	-.107***	-.137	.034	-.098***
Male	.054	.074	.022	.014	.073	.006	-.094	.062	-.038
SEN Status	-.129	.083	-.047	-.028	.087	-.010	.058	.072	.021
EAL Status	.285	.128	.070*	.300	.127	.073*	.015	.106	.004
FSM Ever6 Status	-.242	.099	-.074*	-.155	.100	-.047	-.129	.083	-.039
Y7 CAT Quantitative Score				.014	.004	.159***	.007	.003	.077
KS2 Maths Level				-.003	.012	-.014	-.025	.010	-.097*
Ma Self-efficacy							.513	.029	.488***
Ma Mindset about Intelligence							.209	.032	.178***
R^2		.026			.045			.346	
Adjusted R^2		.020			.038			.340	
ΔR adj ^2					.018			.302	
F		*F* (6,1098)= 4.850***			*F* (8,1096)=6.450***			*F* (10,1094)= 57.958***	

**p* < .05. ***p* < .01. ****p* < .001.

Predicting the Perceived Instrumentality of Mathematics

The same process was repeated for mathematics instrumentality. Demographic characteristics of school, age, gender, Special Educational Needs, English as an Additional Language and Free School Meals Ever status were entered in block 1, accounting for only 4% of all variance in mathematics instrumentality (see Model 1 in Table 8-2). In block 2, the students' Key Stage 2 maths level, as a measure of prior mathematics attainment, and Year 7 quantitative CAT score as a measure of cognitive ability were entered. They only added 0.2% to the prediction of mathematics instrumentality (Model 2). Mathematics self-efficacy and mathematical mindset were entered in block 3, accounting for an additional 15.1% of the variance in mathematics instrumentality (Model 3). Again, age at data collection was negatively correlated with mathematics instrumentality. It was found that English as an Additional Language status positively predicted mathematics instrumentality.

Table 8-2 Results of regression analyses predicting mathematics instrumentality

	Model 1			Model 2			Model 3		
Variable	B	SE	β	B	SE	β	B	SE	β
Intercept	5.389	.474		4.842	.541		3.894	.503	
School 2	.004	.061	.002	.016	.062	.008	-.008	.057	-.004
Age at Data Collection	-.142	.033	-.127***	-.139	.033	-.124***	-.131	.030	-.118***
Male	.097	.058	.049	.081	.059	.041	.033	.055	.017
SEN Status	-.113	.066	-.051	-.071	.069	-.032	-.016	.064	-.007
EAL Status	.436	.101	.134***	.447	.102	.137***	.292	.094	.090**
FSM Ever6 Status	-.039	.078	-.015	-.005	.080	-.002	.014	.073	.005
Y7 CAT Quantitative Score				.004	.003	.051	.000	.003	-.006
KS2 Maths Level				.004	.010	.020	-.008	.009	-.040
Ma Self-efficacy							.263	.026	.314***
Ma Mindset about Intelligence							.160	.028	.171***
R^2		.040			.044			.196	
Adjusted R^2		.035			.037			.188	
ΔR adj ^2					.002			.151	
F		*F*(6,1096)= 7.674***			*F*(8,1094)=6.332***			*F*(10,1092)= 26.590***	

*p < .05. **p < .01. ***p < .001.

Exploring the Possible Mediating Role of Mathematics Self-efficacy in the Relationship Between Mathematical Mindset and Perseverance in Mathematics

The survey data was used to empirically test the hypothesised model of perseverance (see Figure 8-2). To test for mediation, the PROCESS Add-on for SPSS was used (Hayes, 2013). From a simple mediation analysis conducted using ordinary least squares path analysis, mathematical mindset was indirectly associated with mathematics effort regulation through its effect on mathematics self-efficacy (see Figure 8-3). Participants' mathematical mindset (*N*= 1434) was associated with their mathematics self-efficacy (a = .442, *p* <.001) which in turn was associated with the participants' mathematics effort regulation (b = .498, *p* <.001). A bias-corrected bootstrap confidence interval for the indirect effect (ab = .220) based on 10,000 bootstrap samples was entirely above zero (.184 to .260). Mathematical mindset was also associated with mathematics effort regulation independent of its effect on mathematics self-efficacy (c' = .234, *p* <.001).

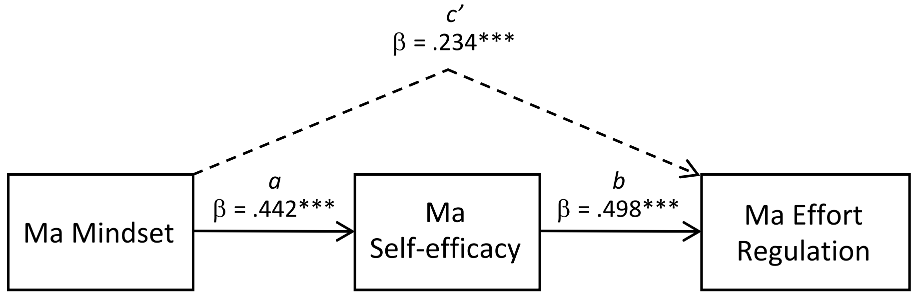

Figure 8-3 Obtained model for mathematics self-efficacy mediating the relationship between mathematical mindset and mathematics effort regulation

The same process was repeated for mathematics instrumentality. From a simple mediation analysis conducted using ordinary least squares path analysis, mathematical mindset was indirectly associated with mathematics instrumentality through its effect on mathematics self-efficacy (see Figure 8-4). Participants' mathematical mindset (N=1430) was associated with their mathematics self-efficacy (a = .440, p <.001) which in turn was associated with mathematics instrumentality (b= .284, p <.001). A bias-corrected bootstrap confidence interval for the indirect effect (ab= .125) based on 10,000 bootstrap samples was entirely above zero (.097 to .156). Mathematical mindset was also associated with mathematics instrumentality independent of its effect on mathematics self-efficacy (c′= .158, p <.001).

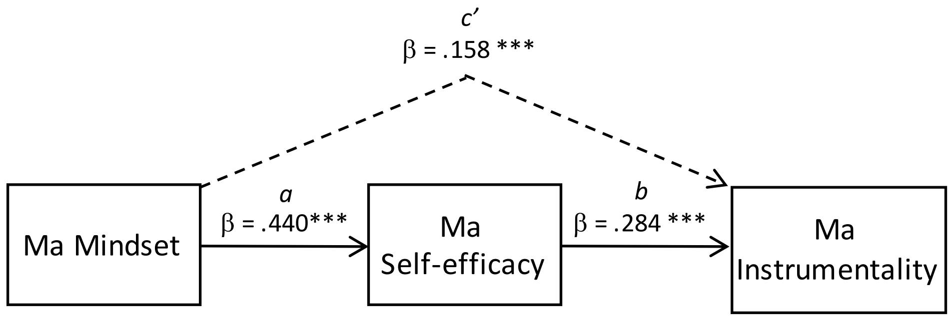

Figure 8-4 Obtained model for mathematics self-efficacy mediating the relationship between mathematical mindset and mathematics instrumentality

The direct effect of mathematical mindset was greater for mathematics effort regulation ($c' = .234$, $p < .001$) compared with ($c' = .158$, $p < .001$) for mathematics instrumentality. The total effect of mathematical mindset on effort regulation was ($c = .454$, $p < .001$), whereas the total effect on mathematics instrumentality was ($c = .282$, $p < .001$).

As can be seen, there was support for the mediating role of mathematics self-efficacy in the relationship between mathematical mindset and the facets of perseverance in mathematics: mathematics effort regulation and mathematics instrumentality.

8.3.2 Promoting Perseverance in Mathematics

The findings from this study were indicative of possible mechanisms for perseverance in mathematics. Specifically, the results suggested that mathematics self-efficacy was associated with both facets of perseverance in mathematics, in particular effort regulation. As a result, a possible approach to enhancing perseverance in mathematics would be to design an intervention that targets mathematics self-efficacy. To that end, it was important to examine the sources of self-efficacy in mathematics for the adolescents in this study.

Using hierarchical multiple linear regression, demographic characteristics of school, age at data collection, gender, Special Educational Needs, English as an Additional Language and Free School Meals Ever status were entered in block 1, accounting for only 4.9% of all variance in mathematics self-efficacy (see Model 1 in Table 8-3). In block 2, the students' Key Stage 2 maths level, as a measure of prior mathematics attainment, and Year 7 quantitative CAT score as a measure of cognitive ability, were entered. They only added 5.3% to the prediction of mathematics self-efficacy (Model 2). The four sources of mathematics self-efficacy (mastery experiences, vicarious experiences, social persuasion and physiological feedback) were entered in block 3, accounting for an additional 44.9% of variance in mathematics self-efficacy (Model 3). Model 3 explained 55.1% of all variance in mathematics self-efficacy, with mastery experiences as the key predictor variable in the model. These findings agreed with previous research and self-efficacy theory (Pajares & Schunk, 2001; Pajares & Urdan, 2006; Usher & Pajares, 2008, 2009), providing further evidence in support of targeting learners' mastery experience in mathematics through an intervention in order to promote self-efficacy in mathematics.

Table 8-3 Results of regression analyses predicting mathematics self-efficacy

	Model 1			Model 2			Model 3		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	4.025	.562		1.736	.623		-.132	.454	
School 2	.046	.072	.02	.079	.071	.034	.059	.051	.025
Age at Data Collection	-.018	.039	-.013	-.009	.038	-.007	.058	.027	.044*
Male	.342	.069	.147***	.270	.068	.116***	.083	.049	.036
SEN Status	-.285	.078	-.108***	-.088	.080	-.033	-.019	.057	-.007
EAL Status	.432	.121	.111***	.492	.118	.126***	.082	.085	.021
FSM Ever6 Status	-.151	.093	-.049	.003	.092	.001	.031	.065	.01
Y7 Quantitative CAT Score				.010	.004	.126**	-.002	.003	-.026
KS2 Maths Level				.034	.011	.144**	-.005	.008	-.021
Mastery Experiences							.443	.040	.403***
Vicarious Experiences							.265	.032	.236***
Social Persuasion							.103	.033	.105**
Physiological Feedback							.137	.025	.138***
R^2		.049			.104			.551	
Adjusted R^2		.044			.097			.546	
ΔR adj ^2					.053			.449	
F		$F(6,1099)= 9.496$***			$F(8,1097)=15.915$***			$F(12,1093)= 111.920$***	

$*p < .05$. $**p < .01$. $***p < .001$.

8.4 Discussion

The aim of this study was to examine the underlying mechanisms of academic perseverance in adolescents. This was achieved by testing the hypothesised model of perseverance in mathematics, focusing on two mathematics-specific measures of perseverance: mathematics effort regulation and mathematics instrumentality. Findings from this study showed that mathematical mindset and mathematics self-efficacy positively predicted both measures of perseverance in mathematics.

Hierarchical multiple linear regression analyses showed that self-efficacy in mathematics and mathematical mindset were significant predictors of these two facets of perseverance in mathematics. Mathematics self-efficacy and mathematical mindset added 30% to the prediction of mathematics effort regulation, while they accounted for an additional 15% to the prediction of mathematics instrumentality.

Furthermore, it appears that the effect of mathematical mindset on perseverance in mathematics was mediated through mathematics self-efficacy, as proposed in the hypothesised model developed as part of this research (see Figures 8-1 and 8-2). As expected, the findings from the mediation analyses also showed that mathematical mindset influenced mathematics effort regulation and mathematics instrumentality independent of its effect on mathematics self-efficacy. These results provided new evidence demonstrating that mathematics self-efficacy had a greater effect on effort regulation (total effect of mathematics self-efficacy on effort regulation = .498 while total effect of mathematical mindset on effort regulation = .454), whereas the total effects of mathematics self-efficacy and mathematical mindset on mathematics instrumentality were very similar (.284 and .282 respectively). The findings of this study are supported by previous research findings showing that when faced with challenge, students with high self-efficacy and a growth mindset were more likely to persevere (Duckworth & Eskreis-Winkler, 2013; Dweck, Walton, & Cohen, 2014; Eskreis-Winkler, 2016; Hochanadel & Finamore, 2015; West et al., 2016; Schunk et al., 2013; Usher & Pajares, 2008; Pajares & Schunk, 2001; Pajares, 1996; Schunk, 1991, 1990).

Whilst there is extensive theoretical support for positive associations between academic self-efficacy, mindset about intelligence and academic perseverance, to date little analytical attention has been paid to examining the processes at play in mathematics. The findings provide initial support for the relationship between mathematical mindset and perseverance in mathematics as a key process, mediated by mathematics self-efficacy (Roney, Rose, & McKeown, in press). These results contribute to the current understanding of perseverance in mathematics amongst adolescents and are also indicative of the underlying mechanisms for perseverance in mathematics. Most promising, these results highlight possible ways to cultivate academic perseverance in adolescents.

8.4.1 Limitations and Implications for Future research

The results of the mediation analyses support the hypothesised theoretical model (Figures 8-1 and 8-2), indicating that a causal relationship is plausible. However, since the data was cross-sectional, conclusions about causality need to be driven by longitudinal mediation analyses (Jose, 2016). A randomised controlled field experiment aims to address this shortcoming in Study 3. Moreover, hierarchical regression analyses further highlighted mastery experiences as the key predictor of mathematics self-efficacy in this sample (see Table 8-3), in agreement with the previous research (Pajares & Schunk, 2001; Pajares & Urdan, 2006; Usher & Pajares, 2008, 2009). These collective findings have implications for the design of an intervention to enhance perseverance in mathematics and will be discussed in depth in Chapter 9. Finally, English as an Additional Language status positively predicted the mathematics instrumentality, suggesting that there may cultural differences in the perceived value of mathematics. This is a question to be addressed by future research.

Chapter 9: Study 3 - Cultivating Academic Perseverance in Mathematics – An Intervention Study

9.1 Background and Rationale

The overarching goal of this study is to enhance perseverance in mathematics amongst adolescents. Positive correlations between academic perseverance and academic self-efficacy has been found in previous research, while the findings from the large-scale survey have highlighted mathematics self-efficacy and mathematical mindset as the key underlying processes for perseverance in mathematics. The present study aims to examine the question of malleability of mathematics perseverance and to provide additional insight into whether perseverance in mathematics can be enhanced through an intervention that manipulates the learners' mastery experience in mathematics. In particular, the impact of enhanced mathematics self-efficacy on mathematics effort regulation, mathematics instrumentality and perseverance in a mathematics-specific task are investigated in a randomised field experiment (N = 152).

9.2 Intervention Studies: A Promising Avenue to Effect Change

> *"Without intervention research, educational researchers are needlessly left on the sidelines when educators ask, "What should I do now in my classroom based on your research?"".*
>
> *Lazowski & Hulleman (2016, p. 629)*

It can be argued that the ultimate goal of any educational research is to impact student outcomes including but not limited to academic achievement. To date, many large-scale policies and programmes have failed to address the interplay between the person and the situation in the study of learning (Rosenzweig & Wigfield, 2016). Moreover, most researchers have little, if any, training or the necessary skills in influencing policy (Lazowski & Hulleman, 2016). By using interventions, researchers can become activists and impact change more directly, instead of waiting for policy changes. Over the years, a great number of interventions (ranging from simple to complex) have been used in varying educational settings with positive outcomes (for reviews see: Rosenzweig & Wigfield, 2016; Lazowski & Hulleman, 2016; Yeager & Walton, 2011). This is promising, especially as some social-psychological interventions have proven to be very powerful as well as time and cost-effective in bringing about positive change in student outcomes (Yeager & Walton, 2011, p. 283).

Drawing inferences based on observational studies may have limited implications for educators and learners. Although correlational research can be used to test hypotheses, it is through intervention studies (defined as "empirical investigations that manipulate an independent variable") that meaningful recommendations that enhance educational outcomes can be offered (Lazowski & Hulleman, 2016, p. 603).

In particular, in recent years, certain types of social-psychological interventions have produced large and lasting effects on a range of student outcomes, including: effort expenditure, persistence and academic achievement (Blackwell et al., 2007; Good, Aronson, & Inzlicht, 2003; Yeager et al., 2016; for reviews see Dweck, Walton, & Cohen, 2014; Yeager & Walton, 2011; Lazowski & Hulleman, 2016). WISE Interventions are single-component, social-psychological interventions designed "to ensure people interpret themselves and social situations adaptively" (Walton & Wilson, 2018, p. 635). These interventions focus on students' inferences about themselves and their context and aim to turn "self-defeating cycles to self-enhancing ones" (p. 639). These brief interventions can be transformational and have been shown to improve academic and interpersonal youth outcomes (Schleider, Mullarkey, & Chacko, 2019; Walton & Wilson, 2018; Yeager & Walton, 2011). It may be hard to believe that brief, inexpensive social-psychological interventions can produce significant and lasting change (Yeager & Walton, 2011), however, this is achieved by targeting the underlying psychological processes that affect the outcomes of interest (Walton & Wilson, 2018; Yeager & Walton, 2011; Nisbett & Ross, 1991). It is by creating recursive processes that the benefits of interventions last and grow beyond the short-term (Eskreis-Winkler et al., 2016). They are "rooted in the scientific premise that people's behavior stems from their interpretations of themselves and their social environment — and that those interpretations are modifiable through targeted, precise interventions" (Schleider et al., 2019, p. 3). More specifically, this approach can be a powerful way to help students achieve their academic goals, by conceptualising their ability beliefs and their learning environment together.

It is believed that brief social-psychological interventions can provide the mechanisms to enable students, especially adolescents, to act more perseverant (Farrington et al., 2012; Dweck, Walton, & Cohen, 2014; Yeager & Walton, 2011; Lazowski & Hulleman, 2016). For instance, a meta-analysis of early self-control interventions (up to age 10) demonstrated that their effectiveness in increasing self-control and perseverance, with effect sizes ranging from 0.28 to 0.61 (Piquero et al., 2010). In a recent longitudinal randomised study with 5th and 6th grade lower-achievers in mathematics, a social-psychological intervention was successfully used to help students persevere even when faced with challenges and obstacles (Eskreis-Winkler et al., 2016). Evidence suggests that despite the fact that it may be difficult to change academic perseverance as a stable trait, it is still possible to change an individual's ability to act perseverant in specific academic settings (Costa Jr & McCrae, 1994; Roberts & DelVecchio, 2000).

From a practical standpoint, since interventions by nature have greater ecological validity, they are more likely to generalise to other settings (Lazowski & Hulleman, 2016). They also enable researchers to make more meaningful recommendations for practice. In summary, intervention studies have the potential to enhance theory, research and educational practice, by building on findings from observational and correlational research. By operationalising theory, intervention studies enable researchers to gain greater insight into the underlying causal relationships and advance their field (Richardson, Abraham, & Bond, 2012). In the present research, using an intervention study made it possible to draw conclusions about the underlying processes for perseverance in mathematics for different learners.

In Study 3, the goal was to design an intervention by drawing on WISE social-psychological interventions, with the hope that the findings from the intervention would inform practice in the future (Lazowski & Hulleman, 2016). Moreover, I was able to draw on my background as a secondary mathematics teacher and apply my understanding of classroom interactions to the intervention design. This understanding, in turn, played a role in considering the scalability of the intervention, with the ultimate goal of teachers delivering it. More importantly, this approach was well-aligned with my pragmatic stance and the notion of radical empiricism for creating usable knowledge and bringing about educational change.

9.3 Examining the Underlying Mechanisms for Perseverance in Mathematics Through an Intervention

To date, limited research has focused on perseverance in mathematics and little analytical attention has been paid to examining the possible causal relationship between mathematics self-efficacy, mathematical mindsets and perseverance in mathematics (Farrington, Levenstein, & Nagaoka, 2013; Muenks, Miele, & Wigfield, 2016; Muenks, Wigfield, Yang, & O'Neal, 2016; Nagaoka et al., 2014). In this research, the findings from Study 2c supported the hypothesised model developed as part of this research (see Figure 8-1), providing initial support for the relationship between mathematical mindset and perseverance in mathematics as a key process, mediated by mathematics self-efficacy (Roney, Rose, McKeown, in press).

Further, the findings from Study 2b showed that effort regulation in mathematics was the key variable explaining the variance in mathematics grades, including future grades and performance against personal targets, with mathematical mindset making a limited contribution to explaining the variance. The total effect of mathematics self-efficacy on effort regulation was found to be greater than the total effect of mathematical mindset on effort regulation. It was, therefore, concluded that to improve students' perseverance in mathematics, the intervention needed to target the students' self-efficacy in mathematics which should in turn impact mathematics effort regulation.

In addition, mathematics self-efficacy is a strong predictor of students' choice of STEM subjects as college majors and degree retention (Hackett & Betz, 1995; Hackett, 1985; Betz & Hackett, 1983). It has also been shown that adolescent students' mathematics self-efficacy specifically influences their STEM-related career choices (Dweck et al., 2014;

Farrington et al., 2012; Dweck, 2012; Blackwell et al., 2007). In fact, it has been suggested that targeting mathematics self-efficacy may potentially improve participation in STEM fields (Dweck et al., 2014; Nagaoka et al., 2014; Farrington et al., 2012; Dweck, 2012). For this reason, the present study aimed to target adolescents' mathematics self-efficacy through an intervention.

Furthermore, the findings from prior research (Schunk & DiBenedetto, 2016; Usher & Pajares, 2009) and Studies 1 and 2c confirmed mastery experiences as the dominant source of mathematics self-efficacy. It can, therefore, be concluded that the intervention would be most effective if it focused on enhancing mathematics self-efficacy by targeting students' mastery experiences in mathematics.

9.4 Aims and Objectives

The overarching aim of the present study was to investigate whether enhancing mathematics self-efficacy could impact perseverance in mathematics. This aim was achieved by addressing the following objectives:

- Designing an intervention that enhanced mathematics self-efficacy;
- Examining the underlying mechanisms for perseverance in mathematics by investigating whether enhancing mathematics self-efficacy impacted perseverance in mathematics.

9.5 Research Design

The use of randomised controlled trials (RCTs) in educational research has become more prevalent in the past 15 years (for a systematic review see: Connolly, Keenan, & Urbanska, 2018). Despite deep skepticism and criticism from some educational researchers, many still believe that RCTs are the gold standard in educational research. More recently there has been growing support for this approach amongst policymakers and funders in the UK (Torgerson, Torgerson, & Director, 2013; Connolly, Keenan, & Urbanska, 2018; Hutchison, Styles, & National Foundation for Educational Research in England and Wales, 2010). Furthermore, RCTs are often used for demonstrating the efficacy of any educational intervention, in order to eliminate selection bias (Torgerson et al., 2013; p. 2). Of course, selection bias is only one source of error in educational research and RCTs do not eliminate other sources, for example: differences in implementers, contextual differences or differences in intensity (Sullivan, 2011). There are also multiple concerns about the high costs and high burdens associated with RCTs, such as: access to participants, low response rates, and the high drop-out rates (Connolly et al., 2018; Sullivan, 2011). Given that the intervention in this study was carried out by a single researcher in a single school, these concerns did not have a major impact on this research. A randomised controlled field experiment was, therefore, adopted as the research design for Study 3, in order to evaluate and determine the efficacy of the mastery experience intervention in mathematics and avoid selection bias.

9.5.1 Theory of Change

As discussed in Chapter 3 (also see Figure 9-1), self-efficacy beliefs are formed based on information received from one of four sources (Bandura, 1997; Usher & Pajares, 2008).

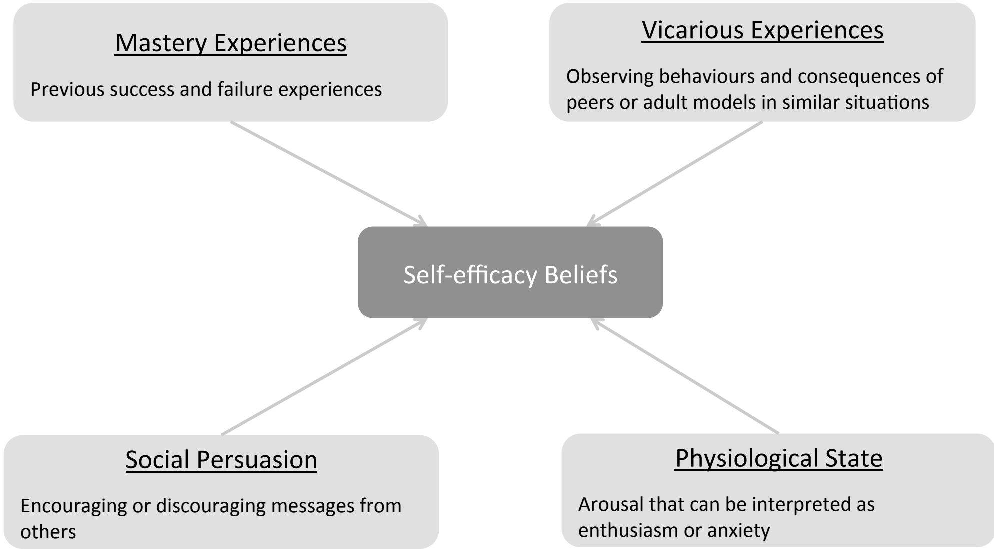

Figure 9-1 Sources of self-efficacy

In order to cultivate academic self-efficacy, one or more of these sources will need to be manipulated by an intervention. Of the four possibilities, it is widely believed that mastery experiences, defined as interpretations of prior performance, are the most influential source of self-efficacy in adolescents (Bandura, 1997; Usher & Pajares, 2008), consistent with the findings from Studies 1 and 2c. It was, therefore, decided to focus the intervention on manipulating mastery experiences in mathematics, in order to enhance mathematics self-efficacy.

When appraising self-efficacy, a student makes inferences by weighing the "relative contribution of ability and non-ability factors to performance successes and failures" (Bandura, 1997, p. 81). This is dependent on a number of factors: the student's perceived ability, task difficulty, effort expenditure, the degree of external help received, the specific circumstances, the patterns of recent successes and failures, and the student's organisation and reconstruction of these patterns in the individual's memory. It has also been found that more recent experiences are often easier to recall and are more likely to influence self-efficacy appraisals (Bandura, 1997).

Succeeding in easy tasks does not require the reappraisal of one's self-efficacy. However, mastering a challenging task carries information about new capabilities. To infer task difficulty, individuals draw on perceived similarity of the task to other experiences and their difficulty level and skill requirements (Trope, 1983). If a student succeeds in a task that is deemed as difficult by others with minimal effort, high ability is inferred. On the other hand, struggling to achieve the same level of success infers lower ability and is less likely to improve self-efficacy beliefs (Bandura, 1997, p. 85). It is only after students feel convinced of their ability to succeed that they are likely to persevere when faced with setbacks and adversity. Overcoming obstacles and setbacks contributes to the cultivation of self-efficacy (Bandura, 1997). This, in turn, results in the development of generative skills required for effective performance, such as: self-regulation and effort-regulation (Bandura, 1986). It is for this reason that mastery experiences are believed to result in stronger efficacy beliefs that are more generalisable. This provides further support for the chosen approach in this study of manipulating mastery experience in mathematics.

Gist and Mitchell (1992) have shown that it is possible to "facilitate the most immediate change in self-efficacy" (p. 183) using interventions. For instance, simply manipulating (by either increasing or decreasing) possible levels of attainment on a task resulted in changes in self-efficacy judgments (Cervone & Peake, 1986; as cited in Gist & Mitchell, 1992). In another study, Cervone (1985) demonstrated that when individuals focused on aspects of a task that were doable, their self-efficacy increased.

To date, most studies of self-efficacy have been focused on the *strength* dimension of self-efficacy rather than its *generality* (Schunk & DiBenedetto, 2016; Honicke & Broadbent, 2016; Kim & Park, 2000). As discussed in Chapter 3, self-efficacy theory defines *generality* of self-efficacy as the transferability of efficacy beliefs to other contexts (Zimmerman, 2000), for instance from algebra to trigonometry. Moreover, evidence suggests that there is a hierarchical structure to general, academic, subject-specific and task-specific self-efficacy (Kim & Park, 2000). In academic settings, it is found that the greater the adolescent students' perceptions of similarity between the tasks, the greater the generality of self-efficacy beliefs (Bong, 1997). In fact, according to Bandura (1986):

> "Once established, enhanced self-efficacy tends to generalize to other situations. As a result, behavioral functioning may improve across a wide range of activities. However, the generalization effects occur most predictably in activities that are most similar to those in which self-efficacy was enhanced." (p. 399).

Beyond the theoretical bases for the intervention design and implementation, three recent reviews of social-psychological interventions (Yeager & Walton, 2011; Lazowski & Hulleman, 2016; Rosenzweig & Wigfield, 2016) were also drawn upon to identify effective self-efficacy interventions in school settings. As can be seen, Figure 9-2 illustrates the theory of change for this intervention, based on the hypothesised model developed as part of this research. The intervention was designed to enhance the students' mastery experience in mathematics with the ultimate goal of enhancing the students' self-efficacy and perseverance in mathematics. In the present study, perseverance in mathematics was operationalised as mathematics effort regulation, mathematics instrumentality and perseverant behaviour in a mathematics-specific task. The details of intervention design are discussed in the following sections.

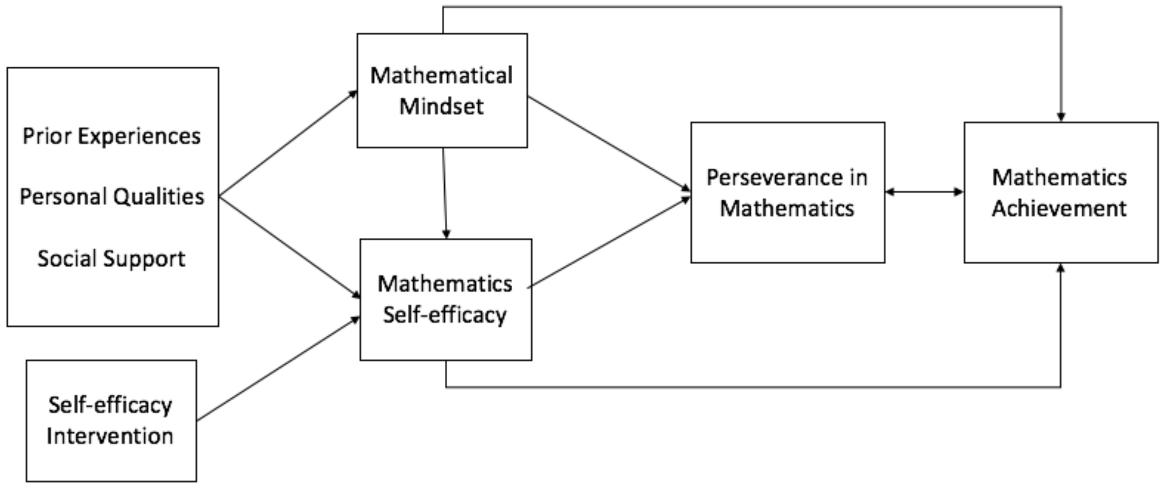

Figure 9-2 Proposed model of change

9.5.2 Development and Design of the Behavioural Task

A multi-dimensional approach was used in order to capture the multiple facets of academic perseverance in mathematics. In recent years, use of more ecologically valid measures to overcome some of the shortcomings of self-report surveys have been promoted amongst educational researchers (American Educational Research Association, 2015; for a review see: Lazowski and Hulleman, 2016). In the present study, use of a behavioural task, along with self-report measures, made it possible to capture the two facets of perseverance, perceived instrumentality and effort regulation in mathematics (see section 7.2 for detailed discussion).

According to Pajares and Miller (1994), "the solving of math problems afforded a clearer and more reliable assessment than was possible in other academic contexts" (p. 200). For this reason, a mathematics problem-solving task was completed by the participants immediately before and after the intervention, as an indicator of their perseverance in mathematics.

To design this task, examples of similar tasks used in previous studies were closely examined. The most notable tasks are described below:

- Academic Diligence Task – a digital task tracking time on mental maths questions versus playing a video game (Galla et al., 2014);
- Time spent on unsolvable puzzles used in multiple studies (for review see Hagger, Wood, Stiff, & Chatzisarantis, 2010);
- Time spent on challenging questions (Blackwell et al., 2007);
- Finding 4 numbers that add up to 100 in a grid (Alan et al., 2015).

After reflecting on the strengths and weaknesses of the possible tasks, including the CountDown task used in Study 1, it was decided to use a task that was not dependent on a student's prior subject knowledge and was not number-centred. Drawing on previous intervention research, a design-based, iterative approach was used to incorporate the key underlying features from the literature to the design of the behavioural task, following a number of small-scale pilots (Blackwell, Trzesniewski, & Dweck, 2007; Galla et al., 2014; Hulleman et al., 2010; Ryan & Deci, 2000; Yeager et al., 2016, for reviews see: Rosenzweig & Wigfield, 2016; Lazowski & Hulleman, 2016).

Initially, the Soma Cube task was chosen as the behavioural task as all students were able to manipulate the pieces and become engaged in the task. The Soma Cube task is a dissection puzzle where seven pieces made up of unit cubes are put together to make a 3 x 3 x 3 cube. The picture below demonstrates one of the many possible solutions to the Soma Cube.

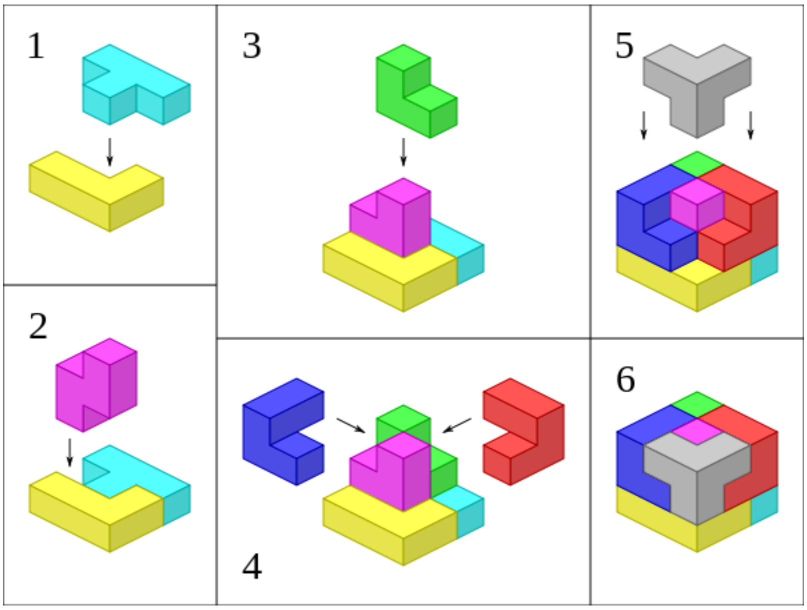

Figure 9-3 One possible solution for the Soma Cube dissection puzzle

Deci and colleagues used the Soma Cube as a behavioural task with graduate students as a measure of motivation (Pink, 2011). To pilot this task, the students were first presented with a completed 3 x 3 x 3 cube and told to try to put the pieces together and find as many different ways as possible to make a 3 x 3 x 3 cube. They were free to stop at any point. By presenting this task as an open-ended investigation, it was hoped that even after completing one or two possible solutions that the students would have still carried on and not seen the task as complete. The maximum time on task was set to 10 minutes, so as not to extend the students' time out of their mathematics lessons for too long. In the first pilot, the students found the task challenging and at times frustrating with most students stopping before seven minutes. The task was similar in nature to other open-ended investigative tasks that students face in their mathematics lessons and for this reason had high ecological validity. However, one key problem with the task was that the students did not see the task as open-ended. In fact, as soon as the students managed to put together the Soma Cube, they then always stopped as they saw the task as complete. This affected use of time on task as a measure of task persistence/ perseverance in mathematics. And whilst, it was possible to control for the number of students' completed solutions, the sheer fact of succeeding or failing at the task was found to interfere with their self-efficacy appraisal and impacted the students' perseverant behaviour. For this reason, it was decided to abandon use of the Soma Cube as the behavioural task.

Instead, it was decided to ask students to complete a number of mathematics related puzzles. Again, these puzzles were not dependent on the students' prior knowledge of mathematics and were *visual mathematics* challenges (recommended by researchers in an attempt to equalise opportunities for all students (Boaler, 2016; West, 2004)). The puzzles were selected from a well-known puzzle book series, Grabarchuk Puzzles (The Grabarchuk Family, 2012). I had previously used these puzzles to design maths challenges in my teaching of secondary school students.

The puzzles were multiple choice. This served two key purposes: firstly, it allowed all students to engage with them even if they were only making a guess about the answer. Secondly, since the students were not given feedback on their answer, they did not know if they were correct or not. This meant that there was little interference with their self-efficacy appraisals. Finally, completing a series of questions, without the certainty of being right or wrong created a situation not unlike that faced by many students completing their homework or a mathematics test. This meant that the task had good ecological validity.

These puzzles were piloted with 10 students. This pilot confirmed that as the puzzles were multiple-choice, all students were able to give answers to the puzzles without knowing if they were right or wrong. This also meant that their self-efficacy was not affected (unlike the Soma Cube task). Moreover, viewing the questions as puzzles resulted in students being comfortable skipping questions or stopping at any point, without the feeling that they were doing anything wrong. The findings from this small pilot demonstrated that the puzzles were suitable to use before and after the intervention, as a behavioural measure of perseverance in mathematics.

Final Behavioural Task Design

The participants were presented with a maximum of 10 questions from puzzle set A (see Appendix E.1.2 for the puzzles and the answers). They were told that as “there are lots of puzzles, you can stop at any point, and I would not be offended” and that “you can skip any puzzles that you do not want to do”. The puzzles were organised into two sets A and B to be completed immediately before (set A) and after (set B) the intervention. The puzzles in each set were matched according to type and level of difficulty (designated by the authors of the puzzle book) to create the highest level of similarity between sets A and B. The maximum number of puzzles was limited to 10 to ensure that the students did not miss too much of their mathematics lesson. Figure 9-4 below shows two examples from the two sets of puzzles.

Set A Set B

Figure 9-4 Examples of puzzles used pre- and post-intervention as a behavioural measure of perseverance in mathematics

9.5.3 Intervention Design Process

The following section describes the design process for the intervention used in the present study. The design was informed by a number of previous intervention studies (Barron & Harackiewicz, 2001; Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Most intervention/experimental studies of self-efficacy in academic settings have manipulated students' mastery or success experiences (For review see: Lazowski & Hulleman, 2016). For instance, Schunk (1985) demonstrated that sixth grade mathematics students improved their self-efficacy beliefs as a result of experiencing mastery by accomplishing their self-set goals. In another study, students who experienced greater success in a subtraction task showed improved self-efficacy (Schunk, 1991). Two studies used a *success versus difficulty* manipulation by teaching undergraduates a new technique for multiplying 2 digit by 2 digit numbers. After learning the technique, the participants were assigned to one of two conditions: *the success condition* with problems similar to those encountered while practising the technique or *the difficulty condition* with more difficult problems (Hulleman, Godes, Hendricks, & Harackiewicz, 2010).

The conditions in this manipulation could be suitably modified to capture interpretations of success and failure, as well as perceived effort expenditure amongst adolescent students. The downside of this manipulation was its reliance on the students' mental maths skills. Especially since it has been shown that focus on number-centred activities in the classroom often results in status differences between students (West, 2004), while it is believed that using visual mathematical tasks and methods have an equalising effect amongst students (West, 2004; Boaler, 2016).

To overcome this shortcoming and remove the need for controlling for the students' mental maths skills and perceived task difficulty (which were difficult to measure for this study), it was decided to use a tangram activity instead of the multiplication task for the intervention in the present research (see Appendix E for materials). The National Centre for Excellence in the Teaching of Mathematics recommends using tangrams as a resource for teaching "Shape and Space". With the exception of a handful of students involved in the present research, most did not have any prior experience with tangrams and therefore did not have specific perceptions about task difficulty. Another advantage of using tangrams was that the task was easy explain and demonstrate to students in any year group from 7 to 11, and no previous knowledge was required. Moreover, all students were able to “play” with the seven pieces and be engaged in the task and not feel left out.

Development of the Experimental Conditions and the Cover Story

The design of the experimental conditions for the intervention relied on the current understanding of self-efficacy theory. For instance, it is postulated that changes in self-efficacy do not arise from successful performances or failures (Bandura, 1982). Rather, it is the processing and interpretation of the information about successes or failures that affects efficacy beliefs (Bandura, 1982). The students’ interpretation of their actual performance in a given task (i.e. mastery experience) provides the most reliable influence on their self-efficacy as the most “tangible indicator of one’s capabilities” (Schunk & DiBenedetto, 2016, p. 35). Successful performances should enhance self-efficacy while failures should result in a decrease in self-efficacy (Bandura, 1997). However, occasional successes and failures after many successes and failures may have limited impact on a student’s self-efficacy. This was an important consideration when designing an intervention to target a student’s mastery experience. Moreover, it has been found that those who only experience “easy” successes are easily discouraged by failure, since they expect effortless results (Bandura, 1982).

Moreover, Bandura (1997) suggests that to develop robust self-efficacy beliefs, individuals need to overcome obstacles through “perseverant effort” (p. 80). This was the reason for the design of the two experimental conditions: *success* versus *challenge conditions*. These conditions were designed such that it could be assumed that students in the *success condition* were likely to breeze through the task (despite finding it non-trivial and effortful to some degree), while those in the *challenge condition* were likely to struggle through the task but nevertheless solve each tangram. However, as discussed in Chapter 3, the students' mindset may also impact their interpretation of effort expenditure, with those with a fixed mindset interpreting the need for perseverant effort as a sign of low ability. This could, in turn, negatively impact their self-efficacy appraisal. Having both the *success* and *challenge conditions* would facilitate a nuanced analysis of the interaction of students' mathematical mindset with the experimental condition as a predictor of their perceived self-efficacy.

Furthermore, prior to taking part in the randomised field experiment, the students would be given a cover story by the researcher. The cover story played a key role in the efficacy of the intervention and as such needed to be informed by evidence from prior research. As in similar intervention studies (Galla et al., 2014; Yeager et al., 2016; Yeager & Walton, 2011), the participants were told that doing well in the tangrams activity would have a positive impact on their overall mathematics performance. The reason for this cover story was twofold. Firstly, as previously highlighted by research, self-efficacy beliefs are specific to the task. It was, therefore, hoped to increase the generalisation of the students' self-efficacy appraisal from the tangram activity to mathematics as a subject. Secondly, by the researcher placing great importance on the tangram activity and emphasising its power to predict future mathematics achievement, it was hoped that even despite the students' prior successes and failures in mathematics as a subject, there was a chance that the students' interpretations of success impacted their mathematics self-efficacy.

At its core, this intervention relied on generalising self-efficacy from the tangram activity to mathematics as a subject. The nature of the tangram activity and its similarity to other mathematical problems encountered in mathematics lessons and the cover story (which further emphasised the notion that doing well in this activity predicted future achievements in mathematics) were designed to improve this generalisation.

Piloting the Intervention Materials

Of course, addressing the question: “can academic perseverance be cultivated by targeting mathematics self-efficacy?” relied upon the success of the intervention in enhancing mathematics self-efficacy. While the mastery experience intervention was based on the design of effective interventions used in previous research, in its current form, it was untested. In order to reduce risks, this intervention was first piloted on a small-scale with 21 students in a different school. Following this small-scale pilot, the participants were consulted, and their feedback was used to refine the intervention. For this pilot, Year 9 students (aged 13-14 years old) from the highest and lowest ability groups from another school served as the sample. The aim of this pilot was to determine the suitability of the tangram activity as the experimental intervention and the students’ response to the experience from both ends of the ability spectrum.

Individual students were taken out of mathematics lessons for 20 to 35 minutes to participate in the pilot (after obtaining consent from the school, parents and students). They were randomly assigned to one of three conditions (seven students per condition) and presented with the seven tangram pieces (see Figure 9-5).

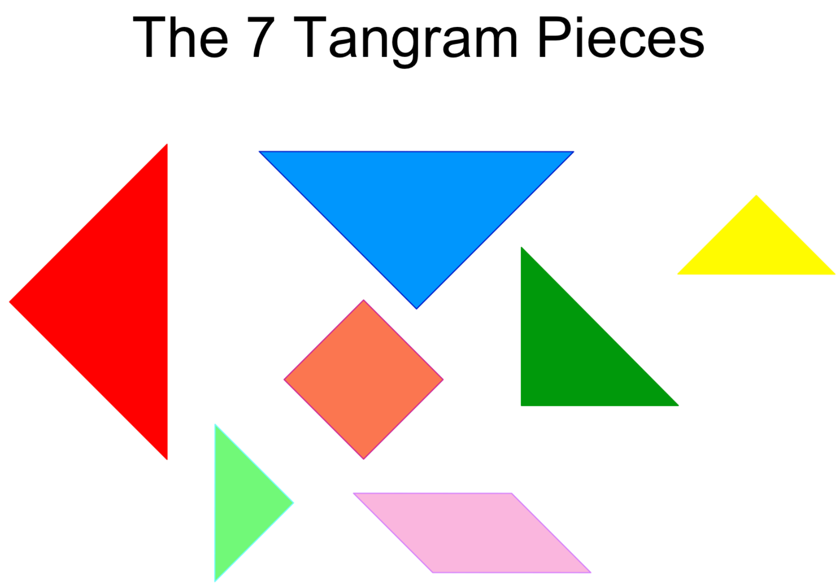

Figure 9-5 The seven tangram pieces used

For the first two tangrams, both conditions received exactly the same instructions. They were given the seven tangram pieces with the solution presented to them as an outline (Figure 9-6). This was to help the participants understand how tangrams work and gain some experience with manipulating the pieces. After the first two tangrams, the two conditions diverged. The conditions for the pilot were as follows:

Condition 1: *Success Condition* – in this condition students completed seven different tangrams with outline solutions presented to help them solve the tangram (see Figure 9-6).

Condition 2: *Challenge Condition* – in this condition students completed the same seven tangrams with no solutions and only the outline of the shape presented to them (see Figure 9-6).

Condition 3: Active Control Group – the students in this group were first shown possible patterns that can be made out of tangrams (see Figure 9-7). They were then asked to play with the tangram pieces to create designs of their choice and give their final design a name.

The students did not need to adhere to any given rules and there were no right and wrong designs. This was to limit any impact on the students' self-efficacy.

The overall verdict from the pilot study was that the intervention was on the whole enjoyable, not too challenging, easy or trivial for the participants, regardless of their mathematics ability group. The pilot also allowed the researcher to get an estimate for the length of time it took the students to complete the intervention.

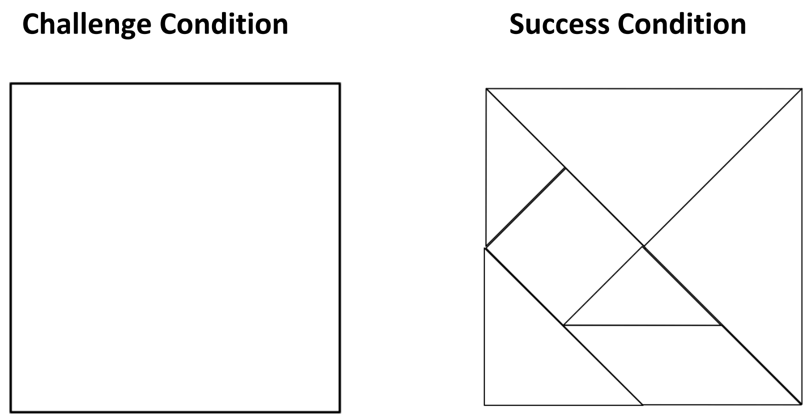

Figure 9-6 Example of the tangram activity for the *challenge* (outline of the square) versus the *success* (the lines showing how the pieces fitted together to create the square in this case) conditions

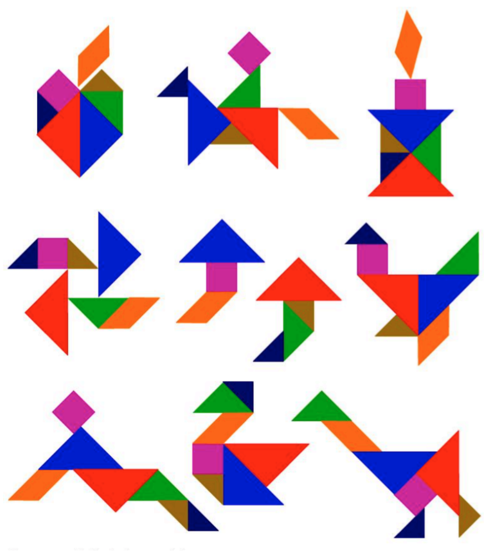

Figure 9-7 The tangram activity for the active control group

As strongly recommended by other researchers (Yeager et al., 2016; Dunning, 2012), the design of the intervention was iterative, was reflected upon and refined. The pilot study resulted in some key changes to the final intervention design, as set out here: Firstly, it was found that the tangram activity was taking a long time to complete. As a result, the number of tangram tasks per condition was reduced to five for the main intervention study. To ensure that the success condition posed sufficient challenge to even the most able participants, they were asked to complete the task as quickly as possible (although the students were not timed). Finally, since some of the students in the challenge condition were stuck on the fourth tangram, it was decided to give the students the option of asking for a hint. This was recorded to capture the students' level of struggle in completing the intervention. The final version of the intervention is presented in the next section.

Final Intervention Design

Prior to taking part in the field experiment, the participants were told that the researcher was interested in the use of games and puzzles in mathematics teaching. The participants were also asked for their date of birth as an additional check for matching their data with the large-scale survey self-report data.

After working through puzzle set A (as a behavioural measure of perseverance), the students completed the experimental treatment or the active control activity based on their condition assignment. Before starting on the tangrams task, the students were told: "You are doing this activity because it can help you in maths. Research shows that this activity makes you a better problem solver . . . The better you do in solving these tangrams, the better you will do in maths in the future."

This cover story was based on Galla and colleagues' research which emphasises the impact of doing a mathematics-specific activity on performance and problem solving in mathematics as a school subject (Galla et al., 2014, p. 317). The participants were then presented with the seven tangram pieces cut out of coloured card (Figure 9-5), and for the first two tangrams participants in both experimental conditions were shown the solution presented to them as an outline used for the *success condition* (Figure 9-6). After the first two tangrams, the two conditions diverged.

Condition 1: *Success Condition* – in this condition, the participants completed three further tangrams (total of five) with outline solutions presented to help them solve the tangram (see Figure 9-6).

Condition 2: *Challenge Condition* – in this condition students completed the same three further tangrams (total of five) with no outline solutions and only the shape presented to them (see Figure 9-6). If the students were stuck, they could ask for a hint and were given a single strategy: "It would be easier to solve this, if you first deal with the two big triangles".

Condition 3: Active Control Group – the students in this group were first shown possible patterns that can be made out of tangrams (see Figure 9-7). They were then asked to play with the tangram pieces to create patterns of their choice and give their final pattern a name. It was emphasised that no specific rules applied and that they could create designs similar to those as shown in Figure 9-7 or to simply create abstract patterns of their own.

The detailed materials and procedures for the tangram activity and puzzles sets A and B can be found in Appendix E.

9.6 Research Questions and Hypotheses

In order to address the main aims and objectives of this study, the following research questions were formulated:

RQ1: To what extent can a mastery experience intervention in mathematics promote self-efficacy in mathematics amongst adolescents?

RQ2: To what extent can a mastery experience intervention in mathematics promote perseverance in mathematics amongst adolescents?

9.6.1 Hypotheses

Based on the theoretical framework for this research and the theory of change proposed for this intervention, it was hypothesised that targeting a student's mastery experience in mathematics would result in the greatest impact on mathematics self-efficacy. This was further supported by the findings of Study 2c which demonstrated that mastery experiences were the key source of mathematics self-efficacy amongst the participants. It was, therefore, hypothesised that if an intervention were to successfully target a student's mastery experience in mathematics, it would promote the student's mathematics self-efficacy. It was further hypothesised that after the intervention, the students in the *challenge condition* would report higher mathematics self-efficacy than those in the *success condition* and the active control group.

As discussed, self-efficacy theory asserts that engaging in "easy" activities can negatively impact self-efficacy and subsequently perseverance, while succeeding in challenging tasks results in enhanced self-efficacy and persistence (Bandura, 1997; Schunk & DiBenedetto, 2016). However, since it was likely that students with fixed mathematical mindsets interpret high effort expenditure (as required in the *challenge condition*) as a sign of low ability (Dweck, 2012), it was postulated that the *success condition* would positively impact their mathematics self-efficacy, while the *challenge condition* would negatively impact it, resulting in an interaction effect between the experimental condition and mathematical mindset.

Given the findings from prior research (Farrington et al., 2013; Muenks, Wigfield, et al., 2016; Muenks, et al., 2017; Nagaoka et al., 2014; Roney, Rose, McKeown, in press) and from Study 2c, it was further hypothesised that if the student's self-efficacy in mathematics was enhanced as result of the mastery experience intervention, then the student's perseverance in mathematics would also be positively impacted.

It is worth noting that in the present study, mathematics effort regulation and mathematics instrumentality were used as measures of perseverance in mathematics, as well as a behavioural task as a behavioural measure of perseverance in mathematics. Closer examination of the items for mathematics effort regulation and mathematics instrumentality highlighted the fact that these two instruments were unlikely to reflect possible increases in mathematics effort regulation and mathematics instrumentality resulting from improved mathematics self-efficacy. Items such as "I work hard to do well in Maths even if I don't like what we are doing" (effort regulation item) or "I do my maths work because getting a good maths grade helps me achieve my future goals" (perceived instrumentality item) are unlikely to shift hugely since they require the student to report their behaviours and beliefs up to that point in time. It was, therefore, hypothesised that while conceptually higher self-efficacy positively impacts mathematics effort regulation and mathematics instrumentality, due to the nature of the self-report measures used, this was unlikely to be reflected in changes in scores on these measures. The students' performance on the behavioural task administered before and after the intervention was, therefore, the key measure of perseverance in mathematics. It was hypothesised that students in the *challenge condition* would outperform those in the *success condition* and the active control group in this task. It was further hypothesised that due to the high degree of similarity between the puzzles behavioural task and the tangram activity (since both can be classified as *visual mathematics* tasks), it would be expected that the effect of increase in tangram-specific self-efficacy (the intervention activity) would generalise to a greater degree to self-efficacy in the puzzles task, compared with self-efficacy in mathematics as a subject.

9.7 Methods

9.7.1 Participants

Power calculations were completed using GPower 3.1, on the basis of testing the primary outcome of increased mathematics self-efficacy across the three experimental conditions, using a one-way between groups analysis of variance. Based on the lower end of effect sizes available for self-efficacy interventions (Lazowski & Hulleman, 2016), an effect size of .2 was assumed with 80% power as recommended in recent research (Chuan, 2006) and $p < .05$. This yielded a total sample size of 148, i.e. approximately 50 students for each experimental condition.

The participants for this study were 152 students from a mixed comprehensive school in England (*M* age = 14.2 years, *SD* = .62). These students had already taken part in the large-scale survey and consented to taking part in the intervention study. It was decided to draw on students from two separate year groups (year 9 and year 10) to lessen the impact of the students sharing their experiences with each other. Prior to data collection, all students who had consented to taking part in the intervention study from years 9 and 10 were put into a spreadsheet and the following steps were used to randomly assign the students to the control and treatment conditions.

Randomisation steps for the 344 students with consent from years 9 and 10 and pre-intervention data are detailed here:

1 - Sort by Student ID ascending

2 - Use Excel [=CHOOSE(RANDBETWEEN(1,3),"Group A","Group B","Group C")] to randomly assign to intervention groups (A & B) or active control group (C)

3 - Use Excel [=CHOOSE(RANDBETWEEN(1,2),"Y","N")] to randomly select participants from all 344 students as participating "Y" or not participating "N"

The generated list was then used to identify individual students and their mathematics class. The list was provided to the class teachers and lessons were identified for when the students were going to be taken out of their mathematics lessons for 30 minutes to participate in this study. If a student was away on that day, the next student on the list was selected. Data collection was continued until enough participants per condition had taken part in the study.

Tables 9-1 summarises the participants' characteristics by condition, as an experimental check.

Table 9-1 Participant characteristics by intervention condition

Participant Characteristics Per Condition	Active Control N = 49		Success Condition N = 51		Challenge Condition N = 52	
% Male	61.2%		49.0%		44.2%	
% Students on SEN Register	8.2%		15.7%		3.8%	
% Students with EAL	26.5%		21.6%		28.8%	
% Students on Free School Meals	30.6%		15.7%		15.4%	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Year Group	9.4	0.5	9.4	0.5	9.3	0.5
Maths Band	2.3	1.0	2.2	1.1	2.2	1.0
Y7 CAT Quantitative Score	103.2	14.5	105.6	15.0	103.4	13.4
Initial Maths Self-efficacy	3.9	1.3	4.0	1.2	4.2	1.3
Initial Maths Mindset	3.9	1.0	3.9	1.0	3.9	1.0
Initial Maths Effort Regulation	4.9	1.2	4.8	1.2	4.6	1.3
Initial Maths Instrumentality	3.5	1.1	3.5	0.9	3.5	1.1

9.7.2 Procedure

Following the data collection in June 2017 for the large-scale survey, parents and students were informed and asked for their consent to participate in a second study commencing in January 2018. The participants were randomly selected from only the students who had parental consent and had agreed to be part of the second study. Nevertheless, due to the power relations that exist between the students, their parents, teachers and the researcher, each participants' verbal consent was again obtained on the day of the experiment.

As an experimental check (see Table 9-1), the participants' demographic characteristics, their maths band and initial self-report scores in mathematics self-efficacy, mathematical mindset, mathematics effort regulation and mathematics instrumentality (which were collected six months prior to the present study as part of the large-scale survey) were found to be comparable between the experimental conditions and the active control group in the present study.

9.7.3 Measures

Demographics, Academic Attainment and Cognitive Ability

This information was collected for each participant when the participants took part in the large-scale survey in June 2017. Participants were asked to report their date of birth in order to correctly match up their data. The school had previously provided the students' Key Stage 2 results for Reading, Writing and Mathematics, as measures of prior attainment (with the parental consent obtained in June 2017). Furthermore, the students' Cognitive Ability Test scores (administered in Year 7), Special Educational Needs (SEN), English as an Additional Language (EAL) and Free School Meals Ever (FSM Ever) status were also provided by the school in June 2017, with parental consent.

Self-report Measures

Mathematics Self-efficacy

Mathematics self-efficacy was assessed using the average score of two items written in accordance with recommendations by Bandura (2006; e.g., "I am confident that I can figure out even the hardest concepts in my maths lessons" and "I am confident that I can understand the material in my maths lesson") on a 6-point scale from strongly disagree to strongly agree with a high score indicating high self-efficacy in mathematics ($\alpha = .83$).

Effort-regulation in Mathematics

The effort regulation scale from the MSLQ (Pintrich et al., 1991) was used to measure effort regulation in mathematics. The scale consists of four items (e.g., "I work hard to do well in this class even if I don't like what we are doing"). Students responded on a scale from 1 = not at all true of me to 7 = very true of me. When responding to the items, participants were asked to think about their current maths lessons (α = .80).

Perceived Instrumentality of Mathematics

Mathematics instrumentality was measured using the 5-item Perceived Instrumentality Scale (Miller, DeBacker, & Greene, 1999) on 5-point scale from 1 = strongly disagree to 5 = strongly agree, with a high score indicating high mathematics instrumentality (α = .88).

Mathematical Mindset

The 2-item mindset self-report scale (Farrington, et al., 2013) was used to determine a learner's implicit mindset about intelligence in mathematics with participants rating their mindset on a 5-point scale (1 = not at all true to 5 = completely true). A high score indicated a growth mindset, whereas a low score indicated a fixed mindset in mathematics (α = .54).

9.7.4 Data Collection Procedures

Prior to starting the experiment, the participants were first asked for their verbal consent and their date of birth as an additional check for matching their data with the large-scale survey self-report data. They were then presented with puzzle set A. After working through the puzzle set A (as a behavioural measure of perseverance), the participants were given the cover story (for details see section 9.5.3) and then completed the experimental treatment, or the active control activity based on their condition assignment.

Immediately after completing the tangram activity, the participants completed a booklet containing self-report measures combined into a single pen and paper survey. Finally, the participants were presented with puzzle set B to measure behavioural perseverance after the intervention. Once all stages of data collection were completed for each participant, the participant was taken back to their lesson and the next participant was taken out of their lesson to begin the experiment. This process was repeated for 152 participants. Figure 9-8 illustrates the steps in data collection for each participant.

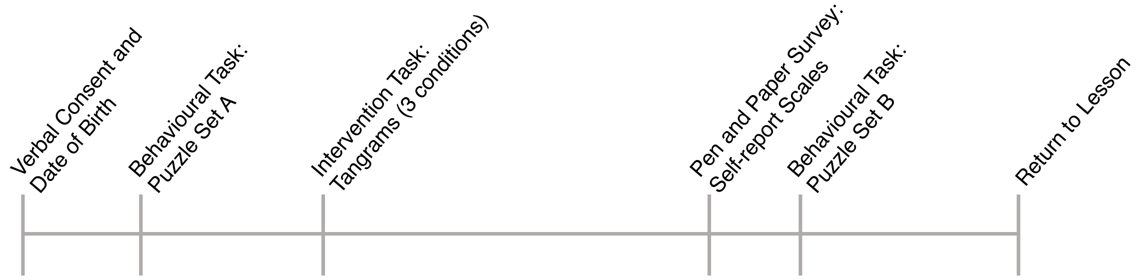

Figure 9-8 Data collection steps for the intervention

9.8 Data Entry, Coding and Missing Data Procedures

To minimise data entry errors, the data was initially entered into Excel cells with validations. This proved extremely useful. As the data was collected from well-established scales, the only consideration for coding was to ensure that reverse-coded items were correctly coded. To ensure overall accuracy in data entry and coding, ten participants were randomly selected. Each item was checked against the data entered and the overall scale was manually calculated and compared with the calculated version. In all ten cases, no errors were observed.

9.9 Analytic Plan

In this randomised controlled field experiment, hierarchical multiple linear regression was used to determine the extent of the impact of the experimental conditions on mathematics self-efficacy, mathematics effort regulation, mathematics instrumentality and performance on the puzzles behavioural task as a measure of perseverance in mathematics. Moreover, a one-way analysis of variance was used to compare the mathematics self-efficacy scores between the control group and the two experimental conditions. Analysis of covariance was then used to compare the participants' performance on the behavioural task after the intervention, controlling for their performance before the intervention.

As previously discussed (see Chapter 3), interpretations of effort expenditure differ amongst learners with fixed versus growth mindsets, with fixed mindset learners appraising high effort expenditure negatively. Interpreting the high effort expenditure required in the *challenge condition* as a sign of low ability was likely to negatively impact the mathematics self-efficacy of participants with fixed mindsets. For this reason, the moderating effect of mathematical mindset was investigated by looking at the interaction term: experimental condition x mathematical mindset, using standardised scores for both variables. It was hypothesised that this interaction term would make a statistically significant contribution in explaining the variance in of the post-intervention mathematics self-efficacy.

9.10 Analyses

9.10.1 Descriptive Data and Zero-order Correlations

The descriptive statistics and zero-order correlations for key variables are summarised in Table 9-2. These are based on self-report measures completed immediately after the intervention.

Table 9-2 Means, standard deviations, and bivariate zero-order correlations for major variables

	1	2	3	4
1. Mathematics Self-efficacy	-			
2. Mathematical Mindset	.256**	-		
3. Mathematics Instrumentality	.517**	.083	-	
4. Mathematics Effort Regulation	.525**	.307**	.522**	-
N	152	152	152	152
M	4.16	4.2	3.71	4.88
SD	1.07	0.9	0.8	1.27

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

9.10.2 Investigating the Impact of the Intervention on Mathematics Self-efficacy

Multiple Linear Regression Analyses

As in previous studies, preliminary analyses were conducted to ensure no violation of the assumptions of regression namely independence of errors, multicollinearity, influential cases in the model and homoscedasticity of residuals.

The relative contribution of the intervention condition on mathematics self-efficacy was examined, using hierarchical multiple linear regression (Table 9-3). Age at data collection, gender, Special Educational Needs, English as an Additional Language and Free School Meals

Ever status, the students' Key Stage 2 maths level (as a measure of prior academic attainment) and Year 7 quantitative CAT score (as a measure of cognitive ability) were entered in block 1, accounting for 14.8% of variance in mathematics self-efficacy (Model 1). The intervention condition added 5.4% to the prediction of mathematics self-efficacy (Model 2), before controlling for initial mathematics self-efficacy (measured in the large-scale survey 6 months prior to the intervention). Initial mathematics self-efficacy accounted for an additional 10% of the variance (Model 3). Model 4 explained 34.3% of all variance in mathematics self-efficacy, with the intervention condition still making a significant contribution to the prediction, even after controlling for initial mathematics self-efficacy. No other variable made a significant contribution to prediction of variance in mathematics self-efficacy.

As highlighted in the analytic plan, the interaction term: Experimental Condition x Mathematical Mindset was entered into the model to test for moderation. This term was found not to make a statistically significant contribution to the prediction.

Table 9-3 Hierarchical multiple linear regression models: mathematics self-efficacy

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	4.862	2.245		4.821	2.176		2.730	2.078		2.795	2.022	
Age at Data Collection	-.159	.144	-.09	-.178	.139	-.101	-.047	.132	-.027	-.069	.129	-.039
Male	.317	.176	.147	.253	.171	.117	.285	.160	.132	.232	.156	.107
SEN Status	-.392	.233	-.14	-.367	.226	-.131	-.246	.214	-.088	-.231	.208	-.082
EAL Status	.464	.196	.189*	.428	.191	.175*	.178	.186	.072	.161	.181	.065
FSM Ever6 Status	-.092	.226	-.034	.006	.221	.002	-.149	.206	-.055	-.063	.202	-.023
Y7 CAT Quantitative Score	-.006	.009	-.080	-.004	.009	-.058	-.011	.008	-.145	-.009	.008	-.123
KS2 Maths Level	.064	.027	.296*	.058	.026	.269*	.050	.024	.231*	.045	.024	.211
Initial Maths Self-efficacy							.389	.071	.435***	.371	.070	.414***
Intervention Condition				.329	.105	.247**				.283	.096	.212**
R^2		.148			.206			.301			.343	
Adjusted R^2		.105			.159			.260			.300	
ΔR adj ^2					.054			.101			.040	
F		*F* (7,137)= 3.405**			*F* (8,136)= 4.407***			*F* (8,136)= 7.320***			*F* (9,135)= 7.848***	

*$p < .05$. **$p < .01$. ***$p < .001$.

One-way Between Groups Analysis of Variance

A one-way between-groups analysis of variance (ANOVA) was conducted to explore the impact of the intervention on participants' mathematics self-efficacy. Participants were divided into three groups according to the intervention condition (Group 0: active control, Group 1: *success condition*, Group 2: *challenge condition*). The Shapiro-Wilk test of normality was statistically significant for the active control, W (49) = .946, p = .027 and the *challenge condition*, W (52) = .945, p = .018. This was not considered problematic as firstly, ANOVA is considered robust with respect to univariate non-normality when group size is greater than 30 (Allen, Bennett, & Heritage, 2014), and secondly, plots of the distribution suggested that the departure from normality was mild.

Levene's test for homogeneity of variances was significant, F (2, 149) = 4.069, p = .019, indicating that assumption of homogeneity of variances in mathematics self-efficacy scores was not met. Since the assumption of homogeneity of variance was not met for this data, the obtained Welch's adjusted F ratio was used, Welch's F (2, 149) = 9.531, p = .001. It was concluded that at least two of the three conditions differ significantly on their average mathematics self-efficacy scores. However, beyond that, Games-Howell post hoc follow-up procedures were conducted to test the difference between all unique pairwise comparisons. The estimated omega squared (ω^2 = .10) indicated that approximately 10% of the total variation in mathematics self-efficacy was attributable to differences between the intervention conditions.

There was a statistically significant difference at the $p < .05$ level in mathematics self-efficacy scores between the *challenge condition* and the two other groups. The effect size was calculated using Cohen's d. Cohen's d was .73 between the *challenge condition* and the active control, and .63 between the *challenge* and *success conditions*, indicating moderate differences between the mean of the participants in the *challenge condition* and the other two groups (Cohen, 1988). Post-hoc comparisons using the Games-Howell indicated that, at the $p < .05$ level, the mean score for the *challenge condition* ($M = 4.61$, $SD = .75$) was significantly higher from the *success condition* ($M = 3.98$, $SD = 1.04$) and the active control group ($M = 3.88$, $SD = 1.23$), as illustrated in Figure 9-9.

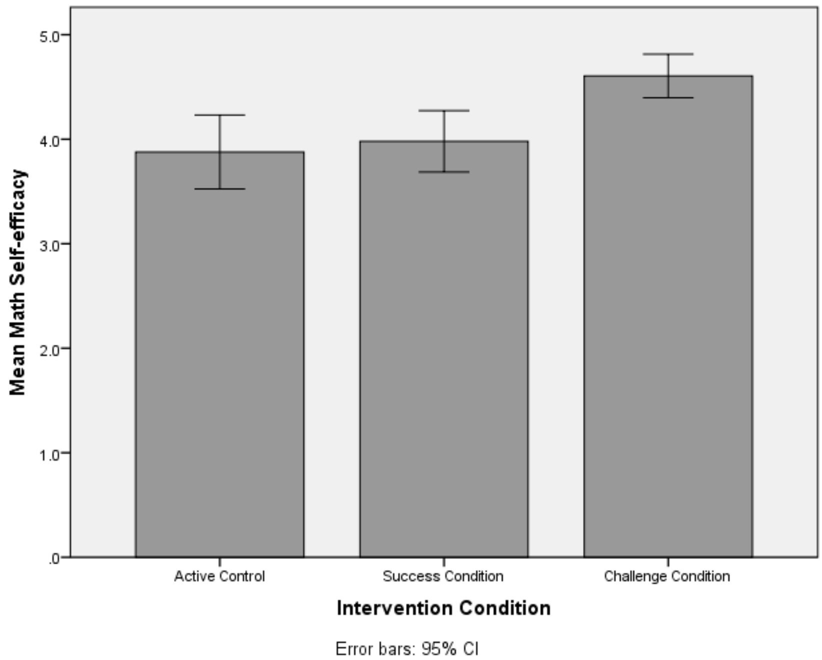

Figure 9-9 Bar chart of the mean of self-efficacy in mathematics by experimental condition

9.10.3 Investigating the Impact of the Intervention on Mathematics Effort Regulation: Multiple Linear Regression Analyses

The same process was repeated for mathematics effort regulation (see Table 9-4). Age at data collection, gender, Special Educational Needs, English as an Additional Language and Free School Meals Ever status, the students' Key Stage 2 maths level (as a measure of prior academic attainment) and Year 7 quantitative CAT score (as a measure of cognitive ability) were entered in block 1, accounting for 4.9% of all variance in effort regulation (Model 1).

The intervention condition accounted for an additional 2.6% of variance in mathematics effort regulation (Model 2), whereas initial mathematics effort regulation alone accounted for an additional 17.2% (Model 3). However, even after controlling for initial mathematics effort regulation, the intervention condition made a significant contribution in explaining the variance in mathematics effort regulation (Model 4).

Table 9-4 Hierarchical multiple linear regression models: mathematics effort regulation

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	2.894	2.812		2.858	2.776		.061	2.563		-.071	2.499	
Age at Data Collection	.050	.180	.024	.034	.178	.016	.126	.162	.06	.109	.158	.052
Male	-.169	.220	-.066	-.224	.219	-.088	-.050	.198	-.02	-.111	.194	-.044
SEN Status	-.132	.292	-.04	-.110	.289	-.033	-.090	.262	-.027	-.062	.255	-.019
EAL Status	.421	.246	.145	.390	.243	.134	.207	.223	.071	.164	.218	.056
FSM Ever6 Status	-.182	.283	-.057	-.098	.282	-.031	-.246	.254	-.077	-.148	.250	-.046
Y7 CAT Quantitative Score	.008	.012	.086	.009	.011	.102	.000	.010	-.003	.001	.010	.013
KS2 Maths Level	.016	.034	.061	.011	.033	.042	.023	.030	.089	.017	.029	.066
Initial Maths Effort Regulation							.498	.084	.457***	.514	.082	.471***
Intervention Condition				.285	.133	.181*				.335	.118	.212**
R^2		.049			.080			.243			.285	
Adjusted R^2		.000			.026			.198			.238	
ΔR adj ^2					.026			.172			.040	
F		$F(7,137)=1.002$			$F(8,136)=1.472$			$F(8,136)=5.453$***			$F(9,135)=5.991$***	

*$p < .05$. **$p < .01$. ***$p < .001$.

9.10.4 Investigating the Impact of the Intervention on Mathematics Instrumentality

Multiple Linear Regression Analyses

Similarly, the same process was repeated for mathematics instrumentality (see Table 9-5). Age at data collection, gender, Special Educational Needs, English as an Additional Language and Free School Meals Ever status, the students' Key Stage 2 maths level (as a measure of prior academic attainment) and Year 7 quantitative CAT score (as a measure of cognitive ability) were entered in block 1, accounting for 15.7% of all variance in mathematics instrumentality (Model 1). In Model 2, the intervention condition did not add to the explanation of variance in mathematics instrumentality, whereas initial mathematics instrumentality accounted for an additional 14.8% (Model 3). Moreover, after controlling for initial mathematics instrumentality, the intervention condition did not make a significant contribution in explaining the variance in mathematics instrumentality (Model 4).

Table 9-5 Hierarchical multiple linear regression models: mathematics instrumentality

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	7.257	1.661		7.250	1.656		5.736	1.536		5.703	1.524	
Age at Data Collection	-.197	.106	-.151	-.203	.106	-.155	-.165	.097	-.126	-.171	.096	-.131
Male	.149	.130	.093	.126	.131	.079	.129	.118	.081	.101	.119	.063
SEN Status	-.119	.174	-.057	-.112	.174	-.053	-.059	.159	-.028	-.050	.158	-.024
EAL Status	.490	.145	.271***	.477	.145	.264**	.309	.136	.171*	.291	.136	.160*
FSM Ever6 Status	.000	.168	.000	.030	.168	.015	.059	.153	.030	.096	.153	.048
Y7 CAT Quantitative Score	.000	.007	-.007	.000	.007	.003	-.005	.006	-.088	-.004	.006	-.077
KS2 Maths Level	-.029	.020	-.182	-.031	.020	-.196	-.016	.018	-.102	-.019	.018	-.117
Initial Maths Instrumentality							.333	.062	.41***	.339	.061	.417***
Intervention Condition				.109	.080	.111				.129	.072	.130
R^2		.157			.169			.309			.325	
Adjusted R^2		.114			.119			.267			.279	
ΔR adj ^2					.005			.148			.012	
F		$F(7,135)=3.599$**			$F(8,134)=3.403$**			$F(8,134)=7.478$***			$F(9,133)=7.106$***	

*$p < .05$. **$p < .01$. ***$p < .001$.

9.10.5 Investigating the Impact of the Intervention on the Behavioural Puzzles Task

Multiple Linear Regression Analyses

Again, the same process was repeated for participants' performance on the behavioural task (see Table 9-6). The participants' performance on the task was measured using the number of correct responses to the puzzles they were presented with, before (P1) and after the intervention (P2). Demographic characteristics, Key Stage 2 maths level and Year 7 quantitative CAT score accounted for 16.2% of the variance in the post-intervention correct puzzles scores (Model 1). The intervention condition added 15.8% to the explanation of variance in the post-intervention correct puzzles scores (Model 2), with the pre-intervention correct puzzles scores adding a further 15.9% in explaining the variance (Model 3). Moreover, after controlling for the pre-intervention correct puzzles scores, the intervention condition made a further 16% contribution in explaining the variance in the post-intervention correct puzzles scores (Model 4).

Table 9-6 Hierarchical multiple linear regression models: performance on the behavioural task (puzzles)

	Model 1			Model 2			Model 3			Model 4		
Variable	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Intercept	3.029	3.443		2.666	3.118		1.005	3.136		.652	2.768	
Age at Data Collection	-.066	.220	-.024	-.105	.200	-.038	.028	.200	.010	-.011	.177	-.004
Male	.048	.272	.014	-.134	.249	-.039	.107	.247	.031	-.075	.220	-.022
SEN Status	-.048	.344	-.012	-.046	.312	-.011	-.056	.311	-.014	-.054	.275	-.013
EAL Status	.134	.306	.034	.066	.277	.017	.119	.276	.030	.052	.244	.013
FSM Ever6 Status	-.226	.348	-.053	.002	.318	.000	-.277	.315	-.065	-.051	.281	-.012
Y7 CAT Quantitative Score	-.020	.014	-.167	-.016	.013	-.136	-.020	.013	-.171	-.017	.011	-.140
KS2 Maths Level	.164	.041	.492***	.155	.037	.464***	.105	.039	.315**	.096	.034	.289**
Pre-intervention Correct Puzzles Score (P1)							.465	.082	.435***	.463	.072	.433***
Intervention Condition				.843	.149	.403***				.839	.132	.401***
R^2		.162			.317			.318			.473	
Adjusted R^2		.120			.278			.279			.439	
ΔR adj ^2					.158			.159			.160	
F		$F(7,141)=3.884$**			$F(8,140)=8.132$***			$F(8,140)=8.175$***			$F(9,139)=13.843$***	

$*p < .05$. $**p < .01$. $***p < .001$.

9.10.6 Analysis of Variance

To simultaneously examine the effects of the intervention on the self-report measures of academic perseverance in mathematics (mathematics effort regulation and mathematics instrumentality), it was initially decided to use multivariate analysis of variance (MANOVA). The Shapiro-Wilk test of univariate normality for effort regulation for the active control group, $W(49) = .913$, $p = .001$, and instrumentality for the active control group, $W(49) = .925$, $p = .004$, was statistically significant. This was not considered problematic as firstly, MANOVA is considered robust with respect to univariate non-normality when group size is greater than 30 (Allen et al., 2014), and secondly, the plots of these distributions suggested that the departure from normality was mild. All other distributions were univariate normal.

All remaining assumptions of non-multicollinearity were satisfied. However, the Levene's test of homogeneity of variances was significant for mathematics effort regulation, $F(2, 149) = 4.469$, $p = .013$, suggesting that the homogeneity of variance-covariance matrices was not satisfied. Since homogeneity of variance could not be assumed for mathematics effort regulation, it was decided to evaluate the impact of the intervention on the dependent variables using ANOVA with a stricter alpha level (.01), instead of a MANOVA, as suggested in the literature (Allen et al., 2014; Field, 2013).

One-way Between Groups Analysis of Variance: Mathematics Effort Regulation

A one-way between-groups analysis of variance (ANOVA) was conducted to explore the impact of the intervention on participants' mathematics effort regulation. Participants were divided into three groups according to the intervention condition (Group 0: active control, Group 1: *success condition*, Group 2: *challenge condition*). The Shapiro-Wilk test of normality was statistically significant for the active control (condition 0), $W(49) = .913$, $p =$

.001. Since ANOVA is considered robust with respect to univariate non-normality when group size is greater than 30, this was not seen as an issue (Allen et al., 2014), and secondly, the plots of this distributions suggested that the departure from normality was mild.

Levene's test for homogeneity of variances was significant, F (2, 149) = 4.469, p = .013, indicating that assumption of homogeneity of variances in mathematics effort regulation scores was not satisfied. Since the assumption of homogeneity of variance was not met for this data, the obtained Welch's adjusted F ratio was used, Welch's F (2, 149) = 5.326, p = .006. It was concluded that at least two of the three conditions differed significantly on their average mathematics effort regulation scores. However, beyond that, Games-Howell post hoc follow-up procedures were conducted to test the difference between all unique pairwise comparisons. The estimated omega squared (ω^2 = .05) indicated that approximately 5% of the total variation in mathematics effort regulation was attributable to differences between the intervention conditions.

There was a statistically significant difference at the p < .01 level (a more stringent level than the usual p < .05) in mathematics effort regulation scores between the *challenge* and the *success conditions*. The effect size was calculated using Cohen's *d*. Cohen's *d* was .69 between the *challenge* and *success* conditions, indicating a moderate difference between the mean of the participants in these two groups (Cohen, 1988). Post-hoc comparisons using the Games-Howell indicated that, at the p < .01 level, the mean score for the *challenge* condition (M = 5.27, SD = 1.05) was significantly higher from the *success* condition (M = 4.60, SD = 1.09), but not significantly different from the active control group (M = 4.77, SD = 1.55), as can be seen in Figure 9-10..

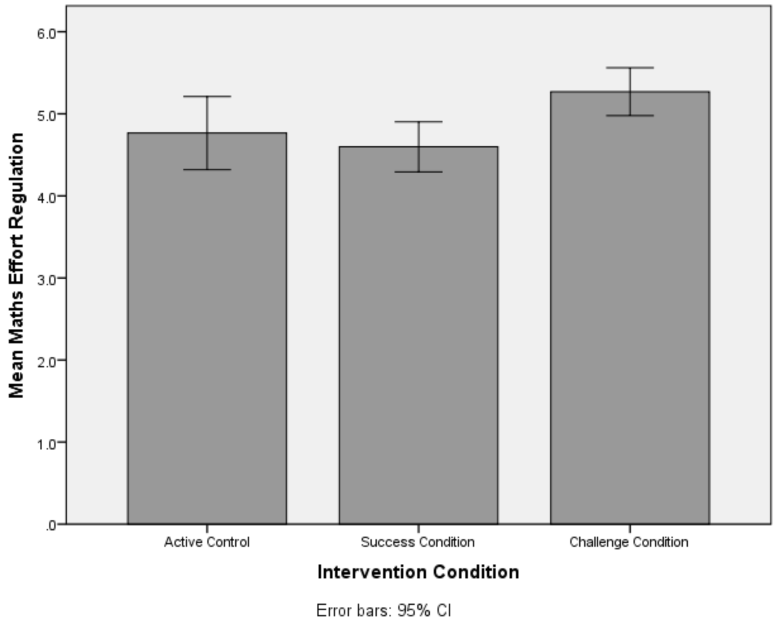

Figure 9-10 Mean of effort regulation in mathematics by experimental condition

The same process was repeated for mathematics instrumentality. No significant differences were found between the mean score of mathematics instrumentality of the three groups, at the $p < .01$ level (see Figure 9-11).

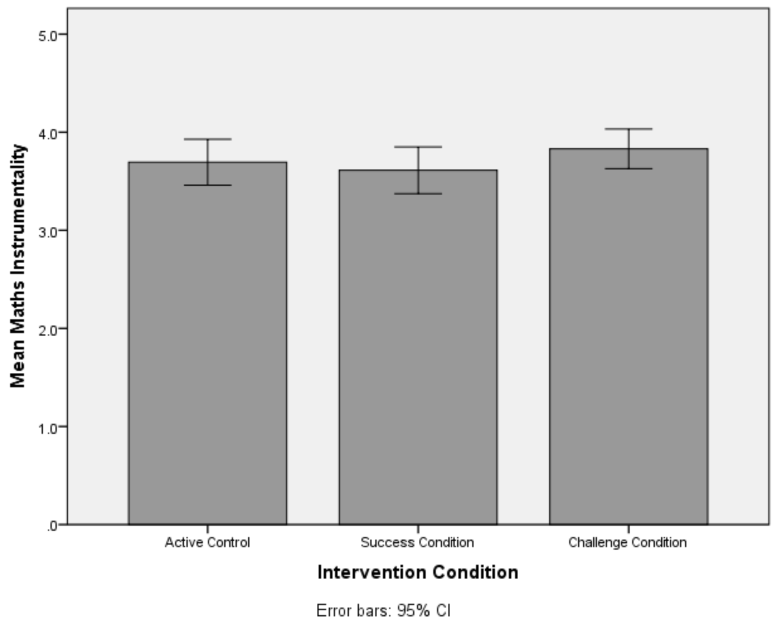

Figure 9-11 Mean of perceived instrumentality of mathematics by experimental condition

9.10.7 One-Way Analysis of Covariance: The Behavioural Task Performance Before and After the Intervention

A one-way analysis of covariance (ANCOVA) was conducted to explore the impact of the intervention condition (Group 0: active control, Group 1: *success condition*, Group 2: *challenge condition*) on participants' performance on the puzzles post-intervention. A covariate was included to partial out the effects of participants' pre-intervention performance on the puzzles from the analysis. The number of correct responses on each puzzle set was used as a measure of their performance.

The Shapiro-Wilk test of normality was statistically significant for the active control, W (49) = .915, p = .002, the *success condition* W (51) = .934, p = .007 and the *challenge condition*, W (52) = .946, p = .019. This was not considered problematic as firstly, ANCOVA is considered robust with respect to univariate non-normality. Moreover, the visual inspection of the histograms, the Q-Q plots and the box plot suggested that the departure from normality was mild.

Scatter plots indicated that the relationship between the covariate (pre-intervention correct puzzle scores) and the dependent variable (post-intervention correct puzzle scores) was linear. Finally, the assumption of homogeneity of regression slopes and homogeneity of variances were supported by the absence of a significant IV-by-covariate interaction, F (2, 146) = .156, p = .856 and a non-significant Levene's test, F (2, 149) = .568, p = .568, respectively.

The ANCOVA indicated that, after accounting for the effects of pre-intervention scores, there was a statistically significant effect of intervention condition on the post-intervention correct puzzles scores, F (2, 146) = 21.524, p <.001, partial η^2 = .228. The effect size was calculated using Cohen's d. Cohen's *d* was 1.52 between the *challenge condition* and active control, and .72 between the *challenge* and *success conditions*, indicating large to moderate differences between the mean of the participants in the *challenge condition* and the other two groups (Cohen, 1988). Post-hoc testing revealed that the participants' post-training scores were highest for those in the *challenge condition*, followed by the *success condition* and the active control groups, even after controlling for pre-intervention scores. Significant differences were observed in all pairwise comparisons.

9.11 Discussion

The overarching goal of the present study was to investigate whether self-efficacy in mathematics can be enhanced by manipulating mastery experience in a mathematics-specific task, namely the tangram activity. As a social-psychological intervention, the tangram activity was designed using an iterative approach, by incorporating the underlying theoretical assumptions of this research (see Chapter 3 and Figure 9-2), and building on recent social-psychological intervention research (for reviews see: Yeager & Walton, 2011; Lazowski & Hulleman, 2016; Rosenzweig & Wigfield, 2016). More specifically, the intervention was refined for optimal implementation with secondary students in their schools, following a small-scale pilot study.

Hierarchical regression analyses showed that after controlling for demographic characteristics, Key Stage 2 mathematics level and cognitive ability and the initial mathematics self-efficacy, the experimental condition significantly explained the variance in mathematics self-efficacy. This was in line with the initial hypothesis, self-efficacy theory and findings from recent social-psychological intervention studies (Bandura, 1997; Schunk & DiBenedetto, 2016; Yeager et al., 2016; Yeager et al., 2014). Moreover, a one-way between-groups analysis of variance (ANOVA) showed moderate differences between the mean of the participants in the *challenge condition* and the other two groups, further demonstrating the impact of the *challenge experimental condition* on participants' mathematics self-efficacy. These results suggest that only the *challenge condition* impacted mathematics self-efficacy. This is well-aligned with self-efficacy theory.

Similarly, it was found that the intervention condition significantly explained the variance in mathematics effort regulation (after controlling for demographic characteristics, Key Stage 2 mathematics level, cognitive ability and the initial mathematics effort regulation). Analysis of variance of the mathematics effort regulation scores between the *challenge* and the *success conditions* showed a moderate difference between the mean of the participants in these two groups. In line with self-efficacy theory, these findings show that the *challenge experimental condition* resulted in students reporting higher mathematics effort regulation compared with those in the *success condition*. Self-efficacy theory asserts that engaging in "easy" activities can negatively impact self-efficacy and subsequently perseverance (Bandura, 1997; Schunk & DiBenedetto, 2016). In this study, the mean score of effort regulation for the students in the *success condition* was lower than the active control group, although this difference was not significant. This provides some evidence that using teaching materials that feel challenging can positively impact self-efficacy and subsequently effort regulation, whereas, giving students teaching materials that they perceive as easy can negatively impact their self-efficacy and effort regulation, yet this is a practice commonly used with students in lower mathematics bands (Francis, et al., 2017).

It is also worth mentioning that effort regulation items such as "I work hard to do well in maths even if I don't like what we are doing" capture behaviour of student in their mathematics lesson to date, rather than their intent for future lessons. It was, therefore, hypothesised that the impact of the intervention on mathematics effort regulation was going to be low due to the nature of the measurement items. Surprisingly, the effect size (d = .69) was larger than expected.

As hypothesised, the intervention did not impact mathematics instrumentality. While mathematics self-efficacy has a positive association with mathematics instrumentality, this study did not provide support for a possible causal relationship.

Hierarchical regression analyses showed that after controlling for demographic characteristics, Key Stage 2 mathematics level, cognitive ability and the number of correct puzzles answered before the intervention, the experimental condition significantly explaining the variance in the number of correct puzzles answered after the intervention. Moreover, a one-way analysis of covariance (ANCOVA) was conducted to explore the impact of the intervention condition on participants' performance on the puzzles post-intervention, using performance on the pre-intervention puzzles score as a covariate. The results indicated large to moderate differences between the mean of the participants in the *challenge condition* and the other two groups. Significant differences were observed in all pairwise comparisons. These findings suggest that both experimental conditions positively explaining the variance in post-intervention performance on the puzzles task. The puzzles behavioural task was used as a more ecologically valid way of capturing perseverant behaviour before and after the intervention. The hypothesised model (see Figure 9-2) proposes that the mastery experience intervention improves self-efficacy in mathematics which in turn enhances perseverance in mathematics. The degree of generalisation of self-efficacy from the tangram activity to other tasks or mathematics as a subject relies on the appraisal of similarity. As previously discussed and demonstrated in prior research (Boaler, 2016; Kim & Park, 2000; Bong, 1999; Bandura, 1986), students were more likely to see greater similarity between the tangram activity and the puzzles behavioural task which are both classed as *visual mathematics*, than with mathematics as a school subject, despite the cover story. For this reason, it was hypothesised that the impact of enhanced self-efficacy in the tangram activity would better generalise to self-efficacy and perseverance in the puzzles task (due to the greater perceived similarity) than to self-efficacy and perseverance in mathematics as a school subject. This hypothesis was supported by the results, further demonstrating the efficacy of the *challenge experimental condition* over the *success condition* and the active control. This may partly explain why the effect sizes for mathematics effort regulation were smaller, as they rely on increases in more general mathematics self-efficacy.

It was further hypothesised that since students with fixed mathematical mindsets were likely to interpret high effort expenditure (required in the *challenge condition*) as a sign of low ability (Dweck, 2012), that the *success condition* would positively impact their mathematics self-efficacy while the *challenge condition* would negatively impact it. To investigate this hypothesis, the interaction term experimental condition x mathematical mindset (using standardised scores) was entered into the regression model. This was found not to make a significant contribution to the explanation of the variance in mathematics self-efficacy following the intervention. Closer examination of the distribution of students' mathematical mindset showed that virtually all students in this study would be categorised as having a growth mindset (the mean scores for the conditions are 3.95 for the active control, 3.94 for the *success condition* and 3.87 for the *challenge condition*). This may explain why the interaction term was not making a statistically significant contribution to the explanation of the variance. Mindsets are a buzzword in schools today and the students' response to these items was likely to have been affected by the social desirability of espousing a growth mindset. In effect, this research has highlighted the difficulties faced for future researchers in capturing the students' true implicit theories of intelligence and avoiding false mindsets, as warned by Dweck (2012). It is also worth noting that the mathematical mindset scale had very low internal consistency ($\alpha = .54$), pointing to possible measurement issues.

Overall, the findings from this study demonstrate that self-efficacy in mathematics can be enhanced by targeting mastery experience using a specific task when the similarities between the intervention and the subject are highlighted through a cover story. Consistent with self-efficacy theory, it was found that the *challenge condition* resulted in the greatest boost in mathematics self-efficacy and mathematics effort regulation.

Establishing that enhancing students' self-efficacy in a given mathematics task can be generalised to mathematics as a school subject is promising and bears direct implications for practice in mathematics classrooms and is a key contribution of this research. The students' perseverant behaviour on the puzzles task demonstrated the efficacy of the *challenge condition*. Further, the results of this study demonstrated that a brief social-psychological intervention has the power to impact students' mathematics self-efficacy and mathematics effort regulation. The present study succeeded in broadening the educational application of promoting self-efficacy in mathematics tasks amongst adolescents. This is of particular importance since enhancing students' self-efficacy beliefs in a specific task provides limited educational benefits (Ahn & Bong, 2019; Schunk & DiBenedetto, 2016; Farrington et al., 2013).

9.11.1 Limitations and Implications for Future Research

Despite the strengths of this study, there are still a number of limitations that need acknowledging. Reflecting on the design of the field experiment, it is important to consider that similar to the activities used in other social-psychological interventions, the tangram activity did not require complex thinking. While this was a feature that was deemed as necessary to ensure students of all abilities could take part in the activity, it did have implications for the ecological validity of the activity, in comparison with the complex thinking required daily in mathematics lessons. In addition, the lasting impact of the intervention on mathematics self-efficacy, mathematics effort regulation and perseverant behaviour in mathematics was not addressed in this study due to access to participants and the limitations imposed by the timeline of the PhD. Further, investigating the impact of increases in self-efficacy and effort regulation on academic achievement was beyond the scope of this study (as set out in the aims). A longitudinal design would have allowed these questions to be addressed. Moreover, the present intervention study was conducted in a single school. A larger sample from different schools would improve the generalisation of the findings.

Upon reflecting on the present intervention, it can be recommended that for future research, the participants' self-efficacy in the tangram activity is also measured. This can help create a clear picture of the extent of generalisation of the task-specific self-efficacy to mathematics self-efficacy. As for the puzzles behavioural task, as a measure of perseverant behaviour, ideally the students should have been given an unlimited or larger number of puzzles to work through. However, to prevent students from missing too much of their mathematics lessons and also to make data collection manageable for the researcher, the number of puzzles was limited to 10 instead. In addition, using time on task during the puzzles behavioural task, alongside the number of correct puzzles answered before and after the intervention, could have provided another dimension for capturing perseverant behaviour. The reason this data was not collected was firstly due to the fact that it may have placed students with lower processing speeds under greater pressure and in turn affected their self-efficacy. Secondly, it would have made data collection in already time-pressured slots more demanding. Nevertheless, putting implementation issues aside, this could have provided valuable data on another aspect of perseverant behaviour.

Despite these limitations, the results of this study hold much promise for the design of future interventions. It is worth noting that this study was considered an efficacy trial, rather than an effectiveness trial. The goal of efficacy studies is to maximise the likelihood of observing an intervention effect if one exists (Nevill, 2016; Singal, Higgins, & Waljee, 2014). More precisely, efficacy can be defined "as the performance of an intervention under ideal and controlled circumstances, whereas effectiveness refers to its performance under 'real-world' conditions" (Singal et al., 2014, p. 1). As discussed, the effect sizes in this study were moderate to large, exceeding expectations based on previous research. This can, in part, be attributed to the fact that the intervention was delivered by the researcher who had designed it, under ideal and controlled conditions. For instance, the impact of the cover story was maximised since the students were far more likely to believe the cover story given by a researcher than a cover story delivered by their maths teacher. This can pose limitations for the scalability of this intervention. According to Bandura (1997), the effectiveness of social persuasion relies on the competence and credibility of the social agent, with varying effects depending on perceptions of the agent. Future effectiveness trials need to, therefore, examine the characteristics of social agents to shed light on the scalability of the intervention, specifically if teachers were to implement the intervention.

Finally, future research can focus on the features of the *challenge condition* to draw more specific conclusions for practice. It is important that future effectiveness trials of this intervention examine the factors that may moderate the intervention's effect in the real world, by addressing questions like: "for whom is this intervention most effective?" and "how long do the effects of the intervention last?" (Rosenzweig & Wigfield, 2016, p. 160; Nevill, 2016). Two other aspects of this intervention design, the length and the strength (referred to as dosage) of the treatment and their relationship to effect size also require closer investigation (Rosenzweig & Wigfield, 2016).

9.11.2 Reflections on the Research Process for the Intervention Study

It is worth reflecting on some of the challenges of conducting educational research in a school, in particular when research requires a heavy burden on participating schools, as was the case in the present study. For instance, in this study, daily co-ordination with class teachers was required for withdrawing individual students from their mathematics lessons, resulting in disruptions to lessons. This study also required access to the school and the students for an extended period of 9 to 10 weeks. Given that the school acted as the gatekeeper to the participants, it was very important to build a strong relationship prior to data collection. This was mainly possible as I was able to draw on my experience as an educator and manage the research process at every stage: from contacting schools, getting consent and access to student data to considering the daily experiences of teachers and students.

By presenting the findings from the survey study to the mathematics department and sharing the aims of the present intervention study, it was possible to get the mathematics department on board despite the demands on the teachers' and students' times and efforts. To get buy in from the staff, three of the teachers were used as participants, each assigned to an experimental condition. They later shared their experience as participants with other teachers in the mathematics department. Involving the staff in the research and taking on board their questions meant that they were invested in the study from the outset and were extremely accommodating during this demanding study. The greatest daily challenge was finding an empty classroom to conduct the intervention. It was not possible to have access to the free rooms timetable or to book rooms in advance and this meant that the first few minutes at the start of every lesson was spent walking around to find a free room. The lack of available and suitable space was one of the key challenges and stresses that I faced daily. All communication to teachers went through the head of department and therefore, I needed to be very mindful of not generating additional work for this person or other staff. Despite advance planning, it was also necessary to be flexible and work around tests, assemblies or other events that resulted in the selected student not being available. It was also important to be extremely organised so as to maximise every minute of each 60-minute lesson time. This meant ensuring that the intervention and behavioural tasks were well planned, prepared and easy to administer.

As can be seen, the burden of this study on the school, teachers and participants (as well as the researcher) were extensive. However, without the insider's knowledge and sensitivity to the teachers' workload and priorities for their students, this research would not have been possible. This highlights some of the challenges of conducting educational research and in particular potential challenges for scalability.

9.12 Conclusions

This study successfully tested the theory of change put forth in section 9.5.1 (see Figure 9-2), using a brief one-to-one social-psychological intervention in mathematics with secondary school students in England. The students were randomly assigned to two treatment conditions and one active control group. The results showed that self-efficacy in mathematics can be successfully enhanced by manipulating mastery experience in a mathematics-specific task. Moreover, the study investigated the impact of enhancing mathematics self-efficacy on measures of academic perseverance such as mathematics effort regulation and perseverant behaviour in a puzzles task before and after the experimental treatment. These results were very promising as they established the efficacy of the *challenge* experimental treatment for generalising task self-efficacy to mathematics self-efficacy, resulting in improvements in perseverance amongst adolescents. Further research needs to focus on effectiveness trials that help extend the intervention's performance under 'real-world' conditions in mathematics classrooms.

Chapter 10: Discussion

Academic perseverance plays a central role in predicting academic achievement and other life outcomes in adolescents (Barshay, 2019; Dweck, Walton, & Cohen, 2014; Farrington, Levenstein, & Nagaoka, 2013; Heckman, Stixrud, & Urzua, 2006; Tangney, Baumeister, & Boone, 2004; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2007; Blackwell, Trzesniewski, & Dweck, 2007). It is further suggested that "increasing students' academic perseverance is appealing as a goal both for education policy and classroom practice." (Farrington et al., 2012, p. 27). The overarching aim of this research was, therefore, to gain a deeper understanding of the complex phenomenon of academic perseverance, its domain-specificity, its underlying mechanisms and whether perseverance in mathematics can be enhanced amongst adolescents.

This research aim was addressed using two quantitative surveys (*N* = 100 and *N* = 1448) and a randomised field experiment (*N* = 152) amongst adolescents attending schools in England. The findings of this research are complex, but in summary, the results show that grit and self-control, as trait-level manifestations of academic perseverance, made negligible contributions in explaining the variance in academic achievement (Study 1), while academic self-efficacy and mindset about intelligence contributed to explaining the variance in academic achievement (Study 2a). Mathematics-specific measures of perseverance were also found superior to trait-level or school-specific measures in explaining the variance in achievement in mathematics (Study 2b and 2c). Moreover, mathematics self-efficacy and mathematical mindset acted as the underlying mechanisms for perseverance in mathematics (Study 2c), with mathematics self-efficacy making a larger contribution to explaining the variance in mathematics effort regulation as a facet of perseverance in mathematics. Therefore, an intervention was designed to target mastery experience in mathematics, as the dominant source of mathematics self-efficacy. In a randomised field experiment (Study 3), mastery experience in mathematics was successfully manipulated, demonstrating impact upon mathematics self-efficacy, mathematics effort regulation and performance in a mathematics task capturing perseverant behaviour. There were significant mean differences between the *challenge experimental condition* and both the *success condition* and the active control group. The findings from Study 3 demonstrated that using a brief social-psychological intervention, it was possible to generalise the participants' mastery experience in a mathematics-related task to mathematics as a subject.

In the sections that follow, key points from Studies 1, 2a, 2b, 2c and 3 are revisited. In order to address each research question, a summary of the evidence is presented again in relation to existing research. Implications for theory and practice (section 10.1), limitations of this research (section 10.2) and future directions (section 10.3) are discussed.

Research Question 1: To what extent, do the trait-level measures of grit and self-control explain the variance in academic achievement in adolescents?

There has been a great deal of interest in examining the incremental validity of grit, its two dimensions and self-control for explaining the variance in academic achievement, with more recent studies reporting weak predictions (Credé, Tynan, & Harms, 2016; Duckworth & Gross, 2014; Muenks, Wigfield, Yang, & O'Neal, 2016; Muenks, Yang, & Wigfield, 2017; Steinmayr, Weidinger, & Wigfield, 2018). This has, in part, been attributed to the fact that, in accordance with their conceptualisation, most researchers have treated these constructs as global traits (i.e. stable across time and situations, rather than domain-specific; Cormier, Dunn, & Causgrove Dunn, 2019; Steinmayr et al., 2018; Duckworth & Gross, 2014). The present research aimed to gain a clearer understanding of the extent to which these trait-level constructs explain the variance in academic achievement in adolescents in England. The findings from Study 1 (*N* = 100) showed that as trait-level constructs, grit, its two dimensions and self-control did not make a statistically significant contribution to explaining the variance in academic achievement as measured by average GCSE points scores or GCSE mathematics grades. While there has been some evidence supporting the incremental validity of grit, its two dimensions and self-control for predicting GPA, it has been found that these trait-level constructs fall short of predicting performance in standardised tests such as the GCSE (Duckworth & Quinn, 2009). GPA captures performance over an extended time period and reflects performance in homework, classwork, tests and examinations. In contrast, standardised tests and examinations like the GCSE only provide a snapshot of the students' performance in a given subject at a given point in time. This may explain why these trait-level constructs failed to contribute to explaining the variance in GCSE scores. However, the students' cognitive ability (as measured by their WAIS composite percentile) and academic self-efficacy contributed to explaining the variance in average GCSE points score accounting for a 12.1% of the variance, with academic self-efficacy accounting for an additional 5.9% of the variance above and beyond the WAIS composite score. The students' cognitive ability (as measured by their WAIS composite score) and mathematics self-efficacy contributed 37.4% to explaining the variance in GCSE mathematics grades, with mathematics self-efficacy accounting for an additional 16.5% of the variance above and beyond the WAIS composite score. In alignment with prior research, these results demonstrate the importance of cognitive ability and domain-specific measures of self-efficacy in explaining the variance in academic achievement as measures by GCSE grades (Finn et al., 2014; Muenks et al., 2017; Steinmayr et al., 2018; West et al., 2014). These findings suggest that the trait-level measures of grit and self-control fall short in explaining the variance in academic achievement due to their lack of specificity to academic settings.

While the sample size for Study 1 was small and student demographic data and current academic grades were unavailable, it is important to conclude that in line with other research findings, academic self-efficacy is a far better in explaining the variance in academic achievement in adolescents, than these trait-level measures of perseverance (Credé et al., 2016; Muenks et al., 2017; Steinmayr et al., 2018). In particular, it was evident that the incremental validity of mathematics self-efficacy for explaining the variance in GCSE mathematics grades surpassed that of academic self-efficacy for explaining the variance in average GCSE points score. This is in line with the literature showing that the more specific the measures of self-efficacy are to a domain, the greater their incremental validity (Bandura, 1997; Schunk & DiBenedetto, 2016; Pajares, 1996). This is further supported by extensive evidence showing that situational demands impact differentially individuals' choice of goals, patterns of perseverant behaviour and achievement in different domains (Cormier et al., 2019; Meyer, Fleckenstein, Retelsdorf, & Köller, 2019; Mischel, 2013; Schunk & DiBenedetto, 2016; Covington, 2000; Pajares, 1996; Ames & Archer, 1988). Further, a recent study offers an alternative explanation for the shortcoming of grit and self-control in explaining the variance in GCSE grades by highlighting differences in the incremental validity of personality traits for academic achievement in different domains (Meyer et al., 2019). For example, it has been found that conscientiousness as a trait predicted mathematics grades in upper secondary students whereas openness as a trait was associated with English grades (Meyer et al., 2019).

The findings from Study 1 raised a key question that was addressed in Study 2: was the failure of these trait-level constructs to explain the variance in grades due to the fact that these measures were not domain-specific i.e. specific to school or mathematics as a school subject? It was hoped that by using domain-specific (school-specific and mathematics-specific) measures of perseverance, the measures would capture the alignment of the individuals' superordinate goals in the given domain and hence improve the measures' incremental validity. This will be discussed in greater detail when addressing RQ3.

Research Question 2: To what extent does the conceptualisation of grit with its two dimensions capture academic perseverance in adolescents?

Grit is defined as a higher order construct, with two lower-order dimensions: *perseverance of effort* and *consistency of interest* (Duckworth et al., 2007; Duckworth & Quinn, 2009). *Perseverance of effort* refers to the tendency to work hard and maintain effort when faced with setbacks and challenges. *Consistency of interest* (also referred to as *passion*; Duckworth & Gross, 2014) is the tendency to maintain interest in goals over a prolonged period of time. Duckworth claimed that both factors combined together have greater predictive power than each factor separately (Duckworth & Quinn, 2009). Yet, there is mounting evidence showing that only the *perseverance of effort* dimension of grit contributes to the prediction of academic achievement (Credé et al., 2016; Duckworth & Gross, 2014; Duckworth & Quinn, 2009; Jachimowicz, Wihler, Bailey, & Galinsky, 2018; Muenks, Wigfield, et al., 2016, 2017; Steinmayr et al., 2018).

Given the findings from Study 1, trait-level grit was adapted to capture school-specific perseverance amongst adolescents in Study 2. It was hoped to examine the incremental validity of each dimension of school grit to untangle whether the low incremental validity of the *consistency of interest* dimension in Study 1 and other research was due to use of the measure's domain-generality. This was especially important since *consistency of interest* is reportedly more likely to be specific to the domain (Cormier et al., 2019; Eskreis-Winkler, 2016; Duckworth & Quinn, 2009).

In sum, it was found that even as a school-specific constructs, school grit and its two dimensions made a *negligible* contribution in explaining the variance in school grades and attendance, beyond demographic measures, prior grades and cognitive ability. Moreover, this contribution was no longer significant after controlling for academic self-efficacy and mindset, further highlighting the importance of academic self-efficacy and mindset for academic achievement. Interestingly, when examining the students' future mathematics GCSE performance (9 months after the survey) against the students' personal targets, the *perseverance of effort* dimension of grit did make a significant contribution, accounting for 2.4% of all variance, even after controlling for mathematics self-efficacy and mathematical mindset. This finding suggests that performing against personal targets may be contingent upon both mathematics-specific self-efficacy, as well as school-specific perseverance. The *consistency of interest* dimension failed to make a significant contribution in any of the models. This may be explained by the fact that the *consistency of interest* dimension used here is a school-specific measure, rather than being specific to mathematics and fails to capture the students' interest in mathematics. Moreover, as discussed in detail in Chapter 2, the *consistency of interest* self-report items require participants to "integrate behaviour over domains" and therefore, fail to capture the alignment of the participants' superordinate goal with the domain of the study (Duckworth & Quinn, 2009, p. 173), suggesting that school grit as a composite measure is not useful for explaining academic achievement.

Finally, as discussed in Study 1, adolescents in England can exercise limited choice in their academic subjects and mathematics is a compulsory subject till age 16. This may account for the fact that the school-specific *consistency of interest* dimension fails to make a contribution to explaining the variance in grades. This dimension may be more appropriate for studying students in their post-16 studies once they have made academic choices, pursuing subjects that interest them. This further indicates that for adolescents, only the *perseverance of effort* dimension provides meaningful insights into academic achievement and that using the composite measure can result in drawing erroneous conclusions about the underlying processes.

Research Question 3: To what extent do domain-specific measures of academic perseverance exceed the incremental validity of trait-level measures for explaining the variance in academic achievement and attendance in adolescents?

Consistent with previous research, findings from Studies 1 and 2a demonstrated that trait-level and school-specific grit and self-control had negligible incremental validity for explaining the variance in academic achievement and academic behaviours such as school attendance, after controlling for the students' demographic characteristics, cognitive ability and prior attainment. The theoretical framework for this research (see Chapter 3) suggested that domain-specific measures of academic perseverance were likely to be superior to trait-level or even school-specific constructs since they better captured the complexities and the interactions between adolescent students and their academic contexts (Pajares & Schunk, 2001; Bandura, 1997; Pajares, 1996). Therefore, using mathematics effort regulation and mathematics instrumentality as mathematics-specific measures of perseverance was likely to improve the explanation of the variance in mathematics grades and students' future academic goals compared with school-specific measures.

It was found that mathematics effort regulation made a significant contribution to explaining the variance in mathematics grade, future mathematics GCSE grade and the students' future achievement against their personal targets in GCSE mathematics courses, above and beyond demographic characteristics, cognitive ability and prior attainment. This contribution held even after controlling for mathematics self-efficacy and mathematical mindset.

Mathematics instrumentality (the extent to which learners perceive performing in the current task as instrumental to achieving personally valued future goals) significantly explained the variance in students' Maths Goal, above and beyond demographic characteristics, prior mathematics attainment and cognitive ability, accounting for 16.4% of all variance. This contribution held even after controlling for mathematics self-efficacy and mathematical mindset, adding a further 10.7% to the explanation of the variance.

As hypothesised, mathematics effort regulation was the key variable explaining the variance in mathematics achievement (as measured by mathematics grades), while mathematics instrumentality was the key variable explaining the variance in students' intentions and goals for pursuing mathematics and mathematics related pursuits post-16. These findings provided further evidence against using a composite measure such as grit, highlighting that use of such a measure would mask the incremental validity of the dimensions. These findings were well aligned with the initial hypotheses. It could, therefore, be concluded that mathematics effort regulation and mathematics instrumentality are conceptually and operationally sound for capturing perseverance in mathematics amongst adolescents, in line with Muenks and colleagues' proposed suggestions (2016, 2017). Moreover, this study highlighted the importance of going beyond grades, in order to capture academic achievement through more meaningful means, such as the students' declared academic and career goals in mathematics.

Research Question 4: What are the underlying mechanisms of academic perseverance in mathematics?

Drawing on the data from the large-scale survey (*N* = 1448), the underlying mechanisms of academic perseverance in adolescents were examined by testing the hypothesised model of academic perseverance (see Figures 8-1 and 8-2), focusing on two mathematics-specific measures of perseverance: effort regulation in mathematics and the perceived instrumentality of mathematics.

Hierarchical multiple linear regression analyses showed that mathematics self-efficacy and mathematical mindsets were significant predictors of these two facets of perseverance in mathematics. Mathematics self-efficacy and mathematical mindsets added 30% to the prediction of mathematics effort regulation, while they accounted for an additional 15% to the prediction of mathematics instrumentality. Furthermore, it appears that the effect of mathematical mindset on perseverance in mathematics was mediated through mathematics self-efficacy (indirect effect). Findings from the mediation analyses showed that mathematical mindset also influenced mathematics effort regulation and mathematics instrumentality independent of its effect on mathematics self-efficacy (direct effect). Furthermore, mathematics self-efficacy had a greater effect on mathematics effort regulation (total effect of mathematics self-efficacy on effort regulation = .498 while total effect of mathematical mindset on effort regulation = .454), whereas the total effects of mathematics self-efficacy and mathematical mindset on mathematics instrumentality were very similar (.284 and .282 respectively). These results were indicative of plausible underlying mechanisms for academic perseverance.

The findings of Study 2c were supported by previous research which showed that when faced with challenge, students with high self-efficacy and a growth mindset were more likely to persevere (Dweck et al., 2014; Nagaoka et al., 2014; Yeager et al., 2016; Yeager & Dweck, 2012; Farrington et al., 2012; Blackwell et al., 2007; Dweck, 2000; Dweck & Leggett, 1988; Schunk et al., 2013; Usher & Pajares, 2008; Pajares & Schunk, 2001; Pajares, 1996; Schunk, 1991, 1990). The collective findings offer initial support for the relationship between mathematical mindsets and perseverance in mathematics as a key process, mediated by mathematics self-efficacy and provide new evidence and contribute to the current understanding of academic perseverance in mathematics in adolescents. As the design of this study was cross-sectional, causal inferences were unwarranted. Nevertheless, the findings are indicative of the underlying mechanisms for perseverance in mathematics and highlight possible ways to cultivate academic perseverance in adolescents. In a randomised field experiment (N = 152), the role of self-efficacy in mathematics as a key underlying process for perseverance in mathematics was examined (Study 3).

Research Question 5: To what extent can a mastery experience intervention in mathematics promote self-efficacy in mathematics amongst adolescents?

Research Question 5a: To what extent can a mastery experience intervention in mathematics promote perseverance in mathematics?

The overarching goal of Study 3 was to investigate whether mathematics self-efficacy can be enhanced by manipulating mastery experience. The findings from this study demonstrated that mathematics self-efficacy could be enhanced by targeting the students' mastery experience, when the similarities between the mathematics-specific task and mathematics as a subject were highlighted through a cover story. In particular and consistent with self-efficacy theory, it was found that the students in the *challenge condition* reported higher mathematics self-efficacy and mathematics effort regulation compared with those in the *success condition* and the active control groups. As previously discussed, Bandura (1997) sees success as vital for developing self-efficacy, although it is believed that those who only experience easy successes are more likely to be discouraged by failure. The *challenge* treatment required the students to master a challenging task, overcoming obstacles through "perseverant effort" and therefore cultivated the students' self-efficacy beliefs (Trope, 1983; Bandura, 1997, p. 80). On the other hand, since succeeding in easy tasks does not require the reappraisal of one's self-efficacy, the impact of the *success condition* on the students' self-efficacy was found to be limited. It is, therefore, not surprising that the students' perseverant behaviour on the puzzles task showed the greatest improvement for the students in the *challenge condition*. This further demonstrates the effectiveness of the *challenge* experimental treatment for enhancing perseverance, providing the most promising results in this research. The findings from this research highlight the positive consequences of feeling challenged in mathematics and are important in providing educators with guiding principles for practice.

10.1 Implications for Research, Theory and Practice

In this section, the implications of the findings for research, theory and practice are discussed here. First, the findings from the quantitative surveys showed that as trait-level and even school-specific constructs, grit, its two dimensions and self-control made limited contributions in explaining the variance in academic achievement in adolescents. Instead effort regulation in mathematics, as a domain-specific measure of academic perseverance in mathematics, was found to be a key variable explaining the variance in academic achievement in mathematics, above and beyond demographic characteristics, measures of cognitive ability and prior attainment in mathematics. This may be, in part, due to the fact that when students respond to self-report measures of trait-level or school-specific constructs, they are in effect integrating their behaviour over different domains (Cormier et al., 2019; Duckworth & Quinn, 2009), resulting in lowering their incremental validity for explaining the variance in academic achievement in a given school subject. It can, therefore, be suggested that subject-specific measures are drawn upon to study perseverance in different school subjects in adolescents.

Second, the survey findings demonstrated that trait-level or school-specific measures fell short of capturing the complexities and the interactions between adolescent students and their academic contexts (Cormier et al., 2019; Schmidt, Fleckenstein, Retelsdorf, Eskreis-Winkler, & Möller, 2017; Duckworth & Quinn, 2009; Pajares & Schunk, 2001; Pajares, 1996). In fact, recent studies have shown that self-reported grit responses differed according the situational context in which they were considered, for instance in mathematics versus in German (Cormier et al., 2019; Schmidt et al., 2017). It is worth highlighting that effort regulation and perceived instrumentality reflect and capture the two facets of academic perseverance: perseverance of effort (resulting in day to day effort regulation in a given subject) and consistency of interest (resulting in continued commitment, course enrolment and retention) and were found to be operationally and conceptually sound for the study of academic perseverance. These results lend further support for the use of domain-specific/ subject-specific measures of perseverance (such as mathematics effort regulation and mathematics instrumentality) for studying perseverance in adolescents across different school subjects.

Third, whilst there was extensive theoretical support in the literature for positive associations between academic self-efficacy, mindset about intelligence and academic perseverance, to date little analytical attention has been paid to examining the underlying processes for academic perseverance (Duckworth & Eskreis-Winkler, 2013; Dweck, Walton, & Cohen, 2014; Eskreis-Winkler, 2016; Hochanadel & Finamore, 2015; West et al., 2016; Schunk et al., 2013; Usher & Pajares, 2008; Pajares & Schunk, 2001; Pajares, 1996; Schunk, 1991, 1990). The findings from Study 2c provided initial support for the relationship between mathematical mindsets and perseverance in mathematics as a key process, mediated by mathematics self-efficacy, adding to the current understanding of the underlying mechanisms for perseverance in mathematics. Understanding these mechanisms can inform design of future interventions that aim to enhance perseverance in mathematics.

Fourth, mathematics self-efficacy was found to be the strongest predictor of effort regulation in mathematics, promoting a new approach to enhancing academic perseverance in mathematics, using a brief social-psychological intervention. The findings demonstrated that self-efficacy in mathematics can be enhanced by targeting the students' mastery experience using a mathematics-specific task (in the case of Study 3 the tangrams activity), when the similarities between the intervention task and mathematics as a subject were highlighted by the researcher through a cover story. Use of social-psychological interventions for enhancing self-efficacy and perseverance in mathematics offers a promising new avenue for future intervention research.

Fifth, the findings from this study highlighted that the students in the *challenge condition* showed significant improvements compared with the *success condition* (who were engaged in a relatively easy task which led to successful outcomes). According to Bandura (1986), by experiencing challenge and rising above it, students became more resilient. This, in turn, results in the development of generative skills required for effective performance, such as improved effort regulation (Bandura, 1986), providing further support for the assertion that mastery experiences result in more generalisable efficacy beliefs (Usher & Pajares, 2008, 2009).

These findings have implications for mathematics educators. Mathematics GCSE examinations have two tiers of entry: foundation and higher. Almost all mathematics departments have policies to help them game the system to achieve the highest possible grade for each student by choosing the tier of entry (Jadhav, 2017). Students may be entered for the foundation tier, if it is believed that they are likely to achieve a higher grade. As previously discussed, for some of these students, the very easy questions on the foundation tier can negatively impact their self-efficacy (Bandura, 1986). Furthermore, mathematics departments often put students in sets/ bands as early as year 7, based on their Key Stage 2 attainment grades, Cognitive Ability Test scores (year 7 CATs) and Family Fischer Trust targets. The students' assignation to a mathematics set/ band or a GCSE tier carries strong messages about the fixed nature of ability in mathematics (Francis, Archer, et al., 2017; Francis, Connolly, et al., 2017; Boaler, 2016; Boaler et al., 2000). It has been found that students in lower sets/bands are often given easier work to help them feel successful (Boaler, 2016). This, in turn, can negatively impact their self-efficacy in mathematics. It is only after students feel challenged and convinced of their ability to succeed that they are likely to persevere when faced with setbacks and adversity (Bandura, 1986). These findings suggest that all students may benefit from feeling challenged in mathematics.

10.2 Limitations

Despite the strengths of this research, there are still a number of limitations that need acknowledging. Whilst 1448 students completed the large-scale quantitative survey, due to the variations in grading criteria and availability of the grades, some of the analyses had to be limited to only a subset of this sample. It would, therefore, be worthwhile to extend this survey to larger samples from different schools in England.

In addition, examining the influence of school-specific constructs on future academic achievement assumes the stability of these constructs over time. This assumption needs to be tested empirically. Whilst the students' grades were collected at two different time points, the students only completed the survey measures once. Using a longitudinal design could have shed greater light on the development of academic perseverance amongst adolescents over time.

The intervention study (Study 3) was focused on testing the relationship between mathematics self-efficacy and perseverance in mathematics. It is important that the hypothesised model developed as part of this research (see Figure 8-1) is tested in its entirety. It is also worth noting that the effect sizes in the intervention study (Study 3) reflect the ideal conditions met on this efficacy trial and are likely to be lower in future effectiveness trials. Nevertheless, the results of this efficacy trial showed promising avenues for future research and its application to the classroom. Future effectiveness trials need to address a number of issues. Firstly, it will be important to examine the extent of transfer from the task to the subject of mathematics. In the present study, the students' self-efficacy in the tangram activity was not measured. For future effectiveness trials, examining the extent of transfer for different groups of students can also yield important information to shape the design and application of the intervention (Singal et al., 2014; Yeager et al., 2016). Secondly, it would worthwhile to investigate the impact of the person giving the cover story and to what degree the students trust their testimony (Harris & Koenig, 2006). This has direct implications for the scalability of this intervention. Finally, the present intervention study did not investigate how long the effects lasted. A longitudinal design can help address this question, however, this was beyond the scope of the present PhD project.

10.3 Future Directions

The findings of the research reported in this dissertation offer exciting new avenues for future research. Most studies of academic perseverance have been focused on the incremental validity of trait-level measures of perseverance for predicting grades (for reviews see: Credé et al., 2016; Farrington et al., 2012; Gutman & Schoon, 2013). Academic achievement in England is still dominantly measured by grades achieved in national examinations such as the GCSE and A level grades. These examinations determine access to further or higher education and impact the career trajectories of students (Deary, Strand, Smith, & Fernandes, 2007; Francis, et al., 2017; Hurst & Cordes, 2017). However, academic achievement is multi-faceted and as such researchers should attempt to capture the different facets by using different outcome variables, in order to enhance the ecological validity of their findings. In this research programme, a number of different variables were used, such as school attendance, students' declared mathematics related academic and career goals and intentions (Maths Goal), and two behavioural tasks (CountDown and the puzzles activity), helping create a more multifaceted picture of academic achievement, as well as academic and perseverant behaviour. Incorporating behavioural measures of perseverance may highlight additional facets of the complex phenomenon of academic perseverance in adolescents, despite the challenges associated with their design and administration. Development and validation of such tasks can positively impact the transfer of research findings to practice and improve the recommendations for practitioners and enhance the current understanding the different facets of academic achievement.

Moreover, the findings from the large-scale quantitative survey suggest that the impact of perseverance constructs for explaining the variance in academic achievement are better captured by, measures that represent the students' performance against their personal targets (such as GCSE mathematics delta used in Study 2). These measures can prove more meaningful than just summative grades in the GCSEs which are only a snapshot in time. It is this gap between the students' academic grades and their personal targets and, not the grades alone, that can shed light on the importance on academic perseverance in adolescents and should be captured in future research.

By distinguishing between the two dimensions of grit, *consistency of interest* and *perseverance of effort*, this research has helped further the current understanding of each dimension's role in explaining academic achievement amongst adolescents. A recent study has further established that these two dimensions, in effect, reflect different aspects of academic achievement (Cormier et al., 2019). The findings of the present research add to the existing literature in challenging the practice of using composite measures such as grit (Cormier et al., 2019; Disabato, Goodman, & Kashdan, 2018; Steinmayr et al., 2018; Muenks et al., 2017; Credé et al., 2016) for future research. Instead these findings promote the development and use of domain-specific measures that reflect these two facets of perseverance, in order to examine their contribution for explaining variance in different academic subjects and achievement settings. For instance, this approach can facilitate comparing a student's achievement and subject-specific self-efficacy and effort regulation in mathematics and English. Examining the within-person similarities and differences that may exist in differing achievement contexts will enable researchers to build a more nuanced picture of academic perseverance amongst adolescents.

Another important contribution of this research is confirming mathematics self-efficacy as the key underlying process for perseverance in mathematics. Mathematics self-efficacy items showed good construct validity and internal consistency (α ranging from .80 to .83 in the 3 studies). The students in all studies found the questions unambiguous and easy to answer. Studies 2b and 2c further confirmed mastery experiences as the key source of mathematics self-efficacy. Mathematics self-efficacy showed high incremental validity for explaining the variance in current and future mathematics grades, mathematics effort regulation and the mathematics instrumentality. It was also found that mathematics self-efficacy can be manipulated with a brief intervention. Given the strength of these collective findings, it can be concluded that focusing on self-efficacy to understand academic perseverance and achievement across different academic subjects can be a promising area for future research, especially since the self-efficacy items can easily be adapted for use in any task or domain.

Further, findings of Study 2b demonstrated that mathematics effort regulation was the key variable explaining the variance in mathematics achievement as measured by mathematics grades, while mathematics instrumentality was the key variable explaining the variance in students' intentions and goals for participating in mathematics and mathematics related pursuits post-16. Further research into development of domain-specific measures capturing both facets of perseverance is likely to yield clearer insights into this complex phenomenon and its impact on outcomes for adolescents across other domains.

As suggested by Yeager and colleagues (2016), an iterative process was adopted for the design of the intervention study and the intervention itself. This approach was critical to the successful implementation of the intervention and to enhancing mathematics self-efficacy and ultimately perseverance in the puzzles behavioural task. While drawing on theory and the research literature provided a solid starting point for the design process, it was extremely important that the research design and the intervention materials were refined after being piloted and reflected upon. It is, therefore, important for future research to address the specific features of the tangram activity and the puzzles behavioural task and examine their role in enhancing mathematics self-efficacy. Addressing these features can inform the process of adapting the *challenge* experimental treatment for use in the classroom and can also impact recommendations to educators.

Inspection of the distribution of the students' mathematical mindset scores highlighted that the vast majority of students identified themselves as espousing a growth mindset. This is at odds with previous research in the US that shows that only 40% of American students have a growth mindset. This may be, in part, due to the rising popularity of the growth mindset research amongst educators in the UK and the use of terminology in schools. In all five schools involved in this research, *growth mindset* was in some form part of each school's intervention policy. This may suggest that students were aware of the social desirability of espousing a growth mindset and this, to some degree, influenced their mindset self-report responses, resulting in declaration of what is referred to as a "false mindset" (Dweck & Yeager, 2019, p. 10). It is, therefore, recommended that researchers are cautious about their interpretations of mindset self-report data. For instance, it may be worthwhile to assess mindset using behavioural tasks or hypothetical choices (similar to those suggested by Mischel (2015) for measuring self-control).

Finally, individual differences in self-efficacy and its determinants affect the degree of malleability of self-efficacy beliefs (Bandura, 1986; Gist & Mitchell, 1992). It has been posited that there is a ceiling effect for raising self-efficacy in individuals' with high self-efficacy (Gist & Mitchell, 1992). If an individual has an accurately low appraisal of their self-efficacy, then it is possible to greatly enhance self-efficacy. On the other hand, if an individual's low self-efficacy is accurately appraised, then the impact of any intervention is likely to be smaller and more short-lived (Gist & Mitchell, 1992). By addressing individual, contextual, and design-related moderating variables, future research will be able to provide more informed and specific recommendations about "for whom and under what conditions this intervention can work best" (Rosenzweig & Wigfield, 2016, p. 160), making more insightful recommendations for educational policy and practice (Lazowski & Hulleman, 2016) .

Chapter 11: Conclusion

This research builds on and contributes to the body of work on academic perseverance, by examining its domain-specificity, its underlying mechanisms and whether perseverance in mathematics can be enhanced amongst adolescents. The backdrop of this research is the growing public interest in grit and self-control, as the key manifestations of perseverance (Clark & Malecki, 2019; Barshay, 2019; Jarret, 2018; Credé et al., 2016; Tough, 2016; Kohn, 2016; Muenks, Wigfield, et al., 2016; Gutman & Schoon, 2013; Farrington et al., 2012). Many educators and policymakers around the world have embraced these constructs, with some hailing them as the panacea to all educational ailments (Barshay, 2019; Clark & Malecki, 2019; Credé et al., 2016; Kohn, 2016; Farrington et al., 2012; Gutman & Schoon, 2013; Jarret, 2018; Muenks, Wigfield, et al., 2016; Tough, 2016). In part, the unabashed enthusiasm for grit can be attributed to its two dimensions: *consistency of interest* and *perseverance of effort*. Grit promises to address two key educational problems at once, especially in STEM fields: the problem of low course enrolment/ retention, as well as the problem of some students not working hard enough day to day/ persevering in school. In addition, whilst grit and self-control are defined as global traits and hence stable across time and situations, their advocates (researchers, educators and policymakers) have been invested in developing educational interventions to increase them (Barshay, 2019; Clark & Malecki, 2019; Credé et al., 2016; Kohn, 2016; Jarret, 2018; Muenks, Wigfield, et al., 2016). This is despite the inconsistent results emerging from the growing body of research on these trait-level constructs' incremental validity for explaining the variance in academic achievement. This research is, therefore, timely and important and as such provides new insights into the domain-specificity of academic perseverance amongst adolescents.

11.1 Contributions

This research contributes to existing literature on academic perseverance by demonstrating that trait-level measures of grit and self-control contribute little in explaining the variance in academic achievement amongst adolescents in England (Study 1). By adapting the GRIT-S and the Brief Self-control Scale, school-specific perseverance was examined. Effort regulation in mathematics and perceived instrumentality of mathematics were used as mathematics-specific measures of perseverance to represent the two facets of academic perseverance –consistency of interest and perseverance of effort. It was found that school-specific measures of grit and self-control added little to explaining the variance in academic achievement and attendance, while the mathematics-specific measures were found superior to trait-level or school-specific measures of perseverance. As such, this research provided additional insight into the domain-specificity of perseverance amongst adolescents in school settings. The findings further demonstrated that academic perseverance is meaningful when studied at the school, subject or task level.

Although numerous studies had examined these perseverance constructs in academic settings (mostly in undergraduate populations), research examining the underlying mechanisms of academic perseverance and its malleability was lacking. Despite the theoretical and empirical justification for self-efficacy and mindsets about intelligence as possible processes for perseverance, little analytical attention had been paid to evaluating the extent of their role for explaining the variance in academic perseverance in adolescents to date. Academic self-efficacy and mindset about intelligence were found to significantly explain the variance in academic achievement and attendance.

Another contribution of this research to the literature was its analytic focus on the underlying mechanisms of academic perseverance in mathematics amongst adolescents. Moreover, this research provided new evidence supporting the relationship between mathematical mindsets and perseverance in mathematics as a key process, mediated by mathematics self-efficacy.

This research succeeded in applying these findings to the design of a social-psychological intervention which targeted students' mastery experience in a mathematics task. In a randomised field experiment, the participant's mastery experience in mathematics was successfully manipulated, demonstrating impact upon mathematics self-efficacy, mathematics effort regulation and performance requiring perseverant effort in a mathematics task. More importantly, the findings from the intervention study showed that it is possible to generalise the participants' mastery experience in a mathematics task to mathematics as a subject.

By investigating whether enhancing students' self-efficacy in a given mathematics task can be generalised to mathematics as a school subject, this intervention study helped broaden the educational application of promoting self-efficacy in mathematics tasks amongst adolescents. The results of this study demonstrated that a brief social-psychological intervention has the power to impact students' mathematics self-efficacy and effort regulation and were indicative of a causal relationship between mathematics self-efficacy and perseverance in mathematics. Most importantly, it was found that the students' perseverant behaviour was positively impacted by the *challenge experimental treatment*. This is particularly promising since it bears direct implications for practice in mathematics classrooms. These findings and the specific design elements of this novel intervention have the potential to provide guidance for the development of educational interventions that cultivate academic perseverance amongst adolescents and to inform practice in the classroom. In sum, this research advances the current understanding of how self-efficacy and perseverance in mathematics can be enhanced. This is a key contribution of this research with promising implications for future research and practice.

11.2 Personal Reflections on the Research Process

I set out to carry out a PhD to deepen my understanding of academic perseverance, with the ultimate goal of impacting students' lives and enhancing their ability to persevere in their academic pursuits. This goal was well-aligned with my pragmatic stance, creating a sense of urgency in my approach to conducting research that was applicable to practice in the classroom. Having completed the research programme, I now have a far greater awareness of the complexities in conducting, analysing and interpreting the findings from my research and the need for taking extreme care in translating the findings into guidelines for practice. Working alongside practitioners, I can see the excitement on their part to readily interpret any correlation as causation and enthusiastically apply the tentative findings in their classroom. I am, therefore, acutely aware of the importance of acting responsibly when communicating research findings.

It is also worth reflecting that the burden of this research programme on the schools, teachers and participants (as well as the researcher) was extensive. More than thirty schools were contacted before five schools agreed to take part in the three studies. Building close relationships with key members of staff, including school data managers was critical to data collection and harmonisation. In particular, without the researcher's experience as an educator and sensitivity to the teachers' workload and priorities for their students, this research would not have been possible. This demonstrates some of the challenges of conducting educational research. Given the need for effectiveness trials before applying the findings from this intervention to practice in the classroom, further highlights the challenges of scalability.

Grit (and the undue attention it has received from educators and policymakers) motivated me to start my research journey, first as an interested educator and later as a critical researcher. Despite the mounting yet inconsistent evidence on its value in educational research, grit has played a key role in the growing interest in academic perseverance and its development (Clark & Malecki, 2019; Jarret, 2018; Steinmayr et al., 2018; Credé et al., 2016; Kohn, 2016; Muenks, Wigfield, et al., 2016; Tough, 2016; Gutman & Schoon, 2013; Farrington et al., 2013). Today, the critiques of grit range from conceptual and methodological to problems with measurement. Some even suggest that grit fails to capture the phenomenon of perseverance in academic settings (Barshay, 2019). Critics warn us against future construct infatuation and the possible impact on resources, policy and practice of embracing the next grit (Barshay, 2019; Jarret, 2018; Kaplan, 2016). Nevertheless, the irony is not lost on me that completing a PhD requires passion and perseverance towards a long-term goal!

On a final note, it seems that, on the one hand, this research has demonstrated the importance of using domain-specific measures of self-efficacy and perseverance amongst adolescents. On the other hand, since students' self-efficacy beliefs in a specific task provide limited educational benefits, this research has demonstrated that it is possible to generalise self-efficacy to a wider domain and reap the educational benefits of such intervention. This highlights the paradox of domain-specificity in the context of educational achievement. It appears that at its core, this research has walked a fine line between how to best capture the complex interactions between adolescents, their context and situational demands, at the same time as broadening the educational benefits of the growing understanding of academic perseverance. An earnest ambition worth persevering toward!

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Appendix A: Ethical Considerations

A.1 Key Ethical Issues for Obtaining University of Bristol, School of Education Ethics Approval for Studies 1 and 2

The British Psychological Society's guidelines and the Bristol School of Education Research Ethics procedures informed the planning and actions of the researcher throughout this study. However, since research entails grappling with ethical decisions throughout every stage, it was helpful to view ethics as an on-going process, rather than a finite event that required completing a form. The following sections summarise and reflect the key ethical considerations for the School of Education Ethics Application that was approved on 12th May 2016 for Study 1 and 18th May 2017 for Studies 2 and 3.

As pragmatic research is judged by its utility (Mertens, 2014), this research was situated in a school setting, to increase the possibility of transfer of findings to other schools. Moreover, the students were likely to be more comfortable at the familiar setting of their own school. The cross-sectional design of Studies 1 and 2 was informed by the need to minimise the burden of data collection on schools and the participants. As a result, the surveys were designed to take no longer than 30 minutes to complete.

More specifically, the following issues were considered and addressed in the Ethics Application for the Studies 1 and 2. The researcher was extremely mindful of adhering to the highest ethical standards throughout the research process.

- **Information given to participants:** I gave a brief explanation about my research, without going into too much detail, prior to the start of the surveys. This was to avoid biasing the participants' responses. A short script was prepared prior to data collection to ensure all points were covered.

- **Participants right of withdrawal and informed consent:** The participants were informed that they were not obliged to take part and that their participation was entirely voluntary. Furthermore, they could withdraw at any point. Consent was obtained from participants (written), parents (opt-out) and the school (verbal), prior to data collection. These two points were of particular importance in working with school-aged learners who often feel that they need to do as they are told or who may be coerced to conform by their teachers. Another ethical issue to consider was the degree to which they understood their rights (Heath et al., 2007). Working with secondary students, I felt confident that they understood their rights. In Study 1, five students exercised their right not to take part in the study and one parent chose to opt out of the study. In Study 2, eleven students exercised their right not to take part and two parents chose to opt out of the study.
- **Anonymity/ confidentiality:** It was important for the participants to trust me as a researcher and feel confident that their results will not be shared with their parents and teachers (to ensure honest responses). The participants were assured that their responses would be kept confidential. Since data collection, the data has been stored securely. The participant names have been removed and replaced with numbers instead in Study 1. In Study 2, students were assigned identification numbers and their demographic data, grades and cognitive ability test results were matched using this identification number, to ensure anonymity.
- **Data storage and Data Protection Act:** The data was collected and processed fairly and lawfully, making the purpose for which it was collected clear to the participants, their parents and the schools. The digital data is stored safely.

- **Access to Demographic Data, Grades, Attendance, Key Stage 2 Results and Cognitive Ability Test Scores:** The schools shared these with me, with the permission of the students and their parents.

A.2 Study 3 Ethical Considerations

The British Psychological Society's guidelines and the University of Bristol, School of Education Research Ethics procedures informed the planning and actions of the researcher during Study 3 and its pilots. The following section summarises and reflects the key ethical considerations for the School of Education Ethics Application that was approved on 18th May 2017.

As the participants were taken out of their mathematics lessons to take part in the study, the time they missed out of their mathematics education was a serious consideration. To minimise this, it was decided to limit the overall time out of the lesson to 30-40 minutes per student and this decision had bearings on the design of the intervention. It was, therefore, important to ensure that the behavioural task and the intervention provided the participants with mental challenge and informal mathematics education instead. In addition, the goal of this study was to enhance self-efficacy and perseverance in mathematics amongst participants, so it was ultimately hoped that the intervention had a positive impact on the participants. This, however, raised a question about the active control group who did not receive the intervention. It was hoped that the greater impact of the possible contribution to knowledge for future mathematics education could justify the time the participants missed out of their formal mathematics education. Since there was a strong possibility that the intervention would have resulted in improvements in academic perseverance in students in the treatment groups, the schools were presented with the findings after the data was analysed, so that other students could also benefit from this research.

Another ethical consideration was dealing with the uncertainty the participants felt in facing unfamiliar tasks and challenges. In a school setting, students are used to getting feedback from their teachers. Yet, in this study, the researcher was unable to acknowledge whether their answers or attempts were correct or successful as this would have impacted the results and introduced bias to the experiment. This left some participants feeling uneasy. And it most certainly left the researcher (as a previous mathematics teacher) uneasy too.

Finally, the participants were given a cover story that doing well in the tangrams activity would have a positive impact on the participants' overall mathematics achievement, similar to cover stories in other intervention studies (Galla et al., 2014; Yeager et al., 2016; Yeager & Walton, 2011). Whilst there is some evidence to support this statement, the extent of the impact was certainly exaggerated. It is worth noting that this statement would not have resulted in any negative impact on the participants.

Appendix B: Measures and Instruments

B.1 Short Grit Scale – GRIT-S

		Not like me at all	Not much like me	Somewhat like me	Mostly like me	Very much like me
		1	2	3	4	5
1	New ideas and projects sometimes distract me from previous ones.					
2	Setbacks (delays and obstacles) don't discourage me. I bounce back from disappointments faster than most people.					
3	I have been obsessed with a certain idea or project for a short time but later lost interest.					
4	I am a hard worker.					
5	I often set a goal but later choose to pursue (follow) a different one.					
6	I have difficulty maintaining (keeping) my focus on projects that take more than a few months to complete.					
7	I finish whatever I begin.					
8	I am diligent (hard working and careful).					

Duckworth, A. L., & Quinn, P. D. (2009). Development and validation of the Short Grit Scale (GRIT–S). *Journal of personality assessment*, *91*(2), 166-174.

* Please note that to capture school-specific grit (as opposed to trait-level grit), the 8-item Short Grit Scale was modified by asking the students to consider each item in relation to their school work (Schmidt et al., 2017).

B.2 Brief Self-Control Scale

		Not like me at all	Not much like me	Somewhat like me	Mostly like me	Very much like me
		1	2	3	4	5
1	I have a hard time breaking bad habits.					
2	I get distracted easily.					
3	I say inappropriate things.					
4	I refuse things that are bad for me, even if they are fun.					
5	I'm good at resisting temptation.					
6	People would say that I have very strong self-discipline.					
7	Pleasure and fun sometimes keep me from getting work done.					
8	I do things that feel good in the moment but regret later on.					
9	Sometimes I can't stop myself from doing something, even if I know it is wrong.					
10	I often act without thinking through all the alternatives.					

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of personality*, *72*(2), 271-324.

* Please note that to capture school-specific self-control (as opposed to trait-level self-control), the 10-item Brief Self-control Scale was modified by asking the students to consider each item in relation to their school work.

B.3 Mindset about Intelligence Scale

		Not at all true	A little true	Somewhat true	Mostly true	Completely true
		1	2	3	4	5
1	My intelligence is something that I can't change very much.					
2	Challenging myself won't make me any smarter.					
3	There are some things I am not capable of learning.					
4	If I am not naturally smart in a subject, I will never do well in it.					

Farrington, C., Levenstein, R., & Nagaoka, J. (2013). " Becoming Effective Learners" Survey Development Project. *Society for Research on Educational Effectiveness*.

B.4 Mathematical Mindset

		Not at all true	A little true	Somewhat true	Mostly true	Completely true
		1	2	3	4	5
1	In Maths, there are some things I am not capable of learning.					
2	If I am not naturally smart in Maths, I will never do well in it.					

Farrington, C., Levenstein, R., & Nagaoka, J. (2013). " Becoming Effective Learners" Survey Development Project. *Society for Research on Educational Effectiveness*.

B.5 Academic Self-efficacy Scale

		Not at all	Not much	Somewhat	Mostly	Very well
		1	2	3	4	5
1	How well can you get teachers to help you when you get stuck on schoolwork?					
2	How well can you study when there are other interesting things to do?					
3	How well can you study a chapter for a test?					
4	How well do you succeed in finishing all your homework every day?					
5	How well can you pay attention during every class?					
6	How well do you succeed in understanding all subjects in school?					
7	How well do you succeed in satisfying your parents with your schoolwork?					
8	How well do you do in tests?					

Muris, P. (2001). Self-Efficacy Questionnaire for Children (SEQ-C). A brief questionnaire for measuring self-efficacy in youths. *Journal of Psychology and Behavioral Assessment, 23*, 145-149.

B.6 Mathematics Self-efficacy PISA

		Very confident	Somewhat confident	A little confident	Not at all confident
		1	2	3	4
1	Using a train timetable to work out how long it would take to get from one place to another .				
2	Calculating how much cheaper a TV would be after a 30% discount.				
3	Calculating how many square metres of tiles you need to cover a floor.				
4	Understanding graphs presented in newspapers				
5	Solving an equation like 3x+ 5= 17				
6	Finding the actual distance between two places on a map with a 1:10,000 scale.				
7	Solving an equation like 2(x+ 3)= (x+ 3)(x−3)				
8	Calculating the petrol consumption rate of a car.				

Ferla, J., Valcke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. *Learning and Individual Differences*, *19*(4), 499-505.

B.7 Sources of Mathematics Self-efficacy

		Definitely False	Very Probably False	Possibly False	Possibly True	Very Probably True	Definitely True
		1	2	3	4	5	6
1	I get excellent grades in Maths tests.						
2	Seeing adults do well in Maths pushes me to do better.						
3	My Maths teachers have told me that I am good at learning Maths.						
4	Just being in Maths class makes feel stressed and nervous.						
5	I have always been successful in Maths.						
6	When I see how a Maths teacher solves a problem, I can picture myself solving the problem in the same way.						
7	People have told me that I have a talent for Maths.						
8	Doing Maths takes all of my energy.						
9	Even when I study very hard, I do poorly in Maths.						
10	Seeing my friends do better than me in Maths pushes me to do better.						
11	Adults in my family have told me what a good Maths student I am.						
12	I start to feel stressed out as soon as I begin my Maths homework.						
13	I got a good grade in my Maths GCSE.						
14	When I see how another student solves a Maths problem, I can see myself solving the problem in the same way.						
15	I have been praised for my ability in Maths.						
16	My mind goes blank and I am unable to think clearly when doing Maths.						
17	I do well on Maths homework.						
18	I imagine myself working through challenging Maths problems successfully.						
19	Other students have told me that I'm good at learning Maths.						
20	I get depressed when I think about learning Maths.						
21	I do well on even the most difficult Maths assignments.						
22	I compete with myself in Maths.						
23	My classmates like to work with me in Maths because they think I'm good at it.						
24	My whole body becomes tense when I have to do Maths.						

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary educational psychology*, *34*(1), 89-101.

B.8 Effort-regulation in Mathematics Items from MSLQ

		Not at all true of me						Very true of me
		1	2	3	4	5	6	7
1	I often feel so lazy or bored when I study Maths that I quit before I finish what I planned to do.							
2	I work hard to do well in Maths even if I don't like what we are doing.							
3	When work in Maths is difficult, I give up or only study the easy parts.							
4	Even when Maths work is dull and uninteresting, I manage to keep working until I finish.							

Pintrich, P. R. (1991). A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).

B.9 Perceived Instrumentality of Mathematics Scale

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
		1	2	3	4	5
1	I do my Maths work because getting a good Maths grade helps me achieve my future goals.					
2	I do my Maths work because getting a good grade is important for achieving my dreams.					
3	I do my Maths work because learning Maths is important for becoming the person I want to be.					
4	I do my Maths work because learning Maths is important for achieving my dreams.					
5	I do my Maths work because learning Maths helps me achieve my future goals.					

Miller, R. B., DeBacker, T. K., & Greene, B. A. (1999). Perceived instrumentality and academics: The link to task valuing. *Journal of Instructional Psychology*, *26*(4), 250.

Appendix C: Study 1

C.1 Data Harmonisation and Coding

A key challenge in Study 1 was data harmonisation. GCSE results were provided in many different formats (even for different students in the same school). For instance, calculating the GCSE Science score was challenging as some students had taken three separate subjects (counting as three GCSEs), others had Science as a double award and some had taken Science as a single subject (due to not meeting all the requirements for the double award). These were important considerations for calculating average GCSE Points scores.

Also, as a behavioural measure of grit and self-control, I wanted to use the academic behavioural data such as attendance, non-compliant behaviours (suspensions, detentions, classroom disruption or not completing homework) and rewards for excellent work. However, as the schools in the study assume that Sixth Form students choose to pursue their studies by their own volition, other than attendance, this data was not collected beyond year 11. As most of the rest of the data was collected from well-established scales, the only consideration for coding was to ensure that reverse-coded items were correctly coded. To ensure overall accuracy in data entry and coding, ten participants were randomly selected. Each item was checked against the data entered and the overall scale was manually calculated and compared with the calculated version. In all ten cases, no error was observed.

C.2 Scree Plots of Grit and Self-control Items

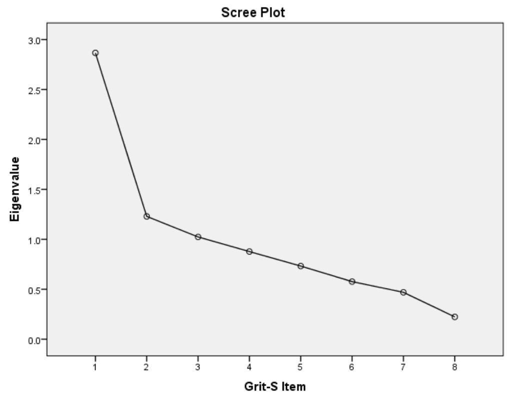

Figure C-1 Scree plot of the 8 items of the Short Grit Scale

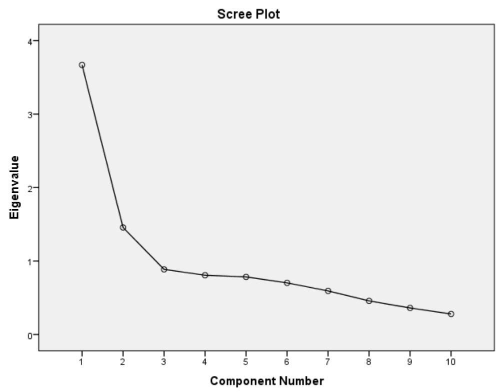

Figure C-2 Scree plot of the 10 items of the Brief Self-control Scale

Appendix D: Study 2a

D.1 Scree Plots of School-specific Grit and Self-control

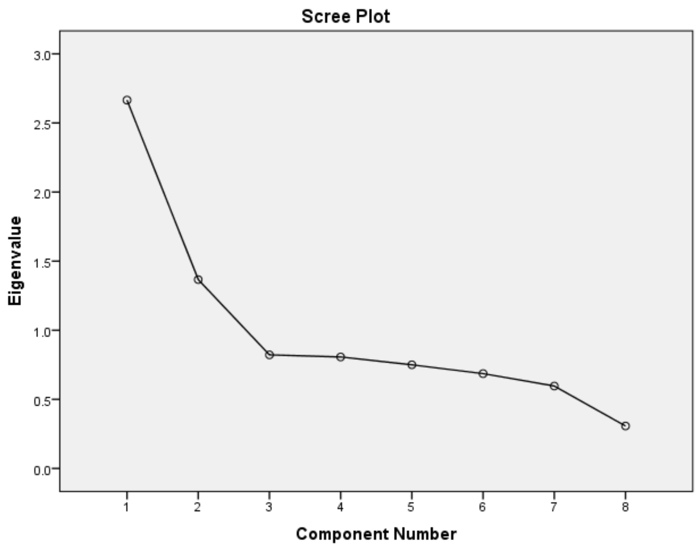

Figure D-1 Scree plot of the 8 items of the school-specific Short Grit Scale

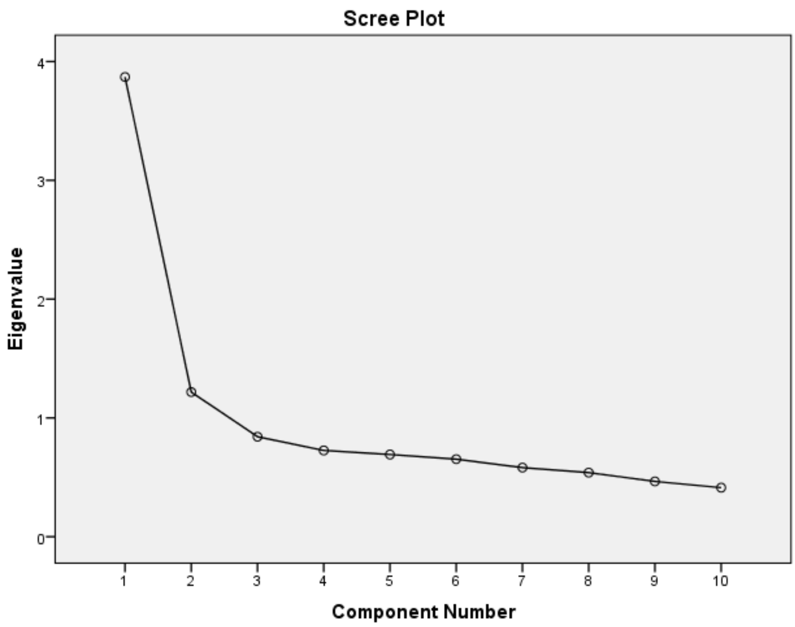

Figure D-2 Scree plot of the 10 items of the school-specific Brief Self-control Scale

Appendix E: Study 3

E.1 Intervention Procedures and Study 3 Materials

Prior to taking part in the field experiment, the participants were told that the researcher was interested in using games and puzzles in mathematics teaching. The participants were also asked for their date of birth as an additional check when matching their data with the large-scale survey self-report data. They were then presented with up to 10 questions from puzzle set A. They were told that as “there are lots of puzzles, you can stop at any point, and I would not be offended” and that “you can skip any puzzles that you do not want to do”. The puzzles were organised into two sets A and B to be completed immediately before (set A) and after (set B) the intervention. The puzzle in each set were matched according to type and level of difficulty (designated by the authors of the puzzle book) to create the highest level of similarity between sets A and B. The maximum number of puzzles was limited to 10 to ensure that the students did not miss too much of their mathematics lesson.

After working through the puzzles in set A (as a behavioural measure of perseverance), the students completed one of the experimental treatments or the active control activity based on their condition assignment. Figure E-1 demonstrates the data collection steps for the intervention.

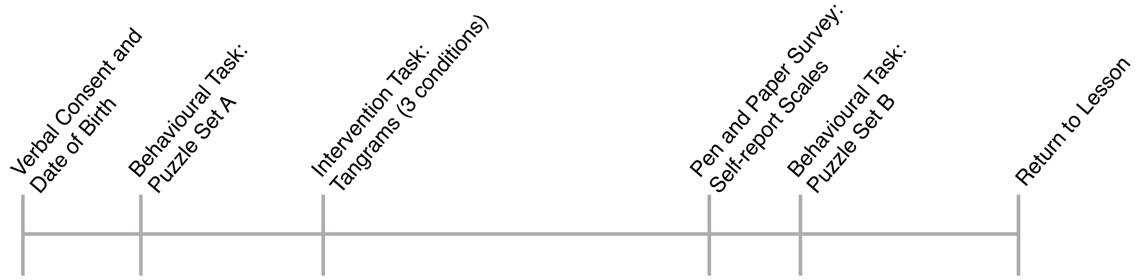

Figure E-1 Data collection steps for the intervention

E.1.1 Tangrams

The students were given seven coloured tangram pieces (shown below).

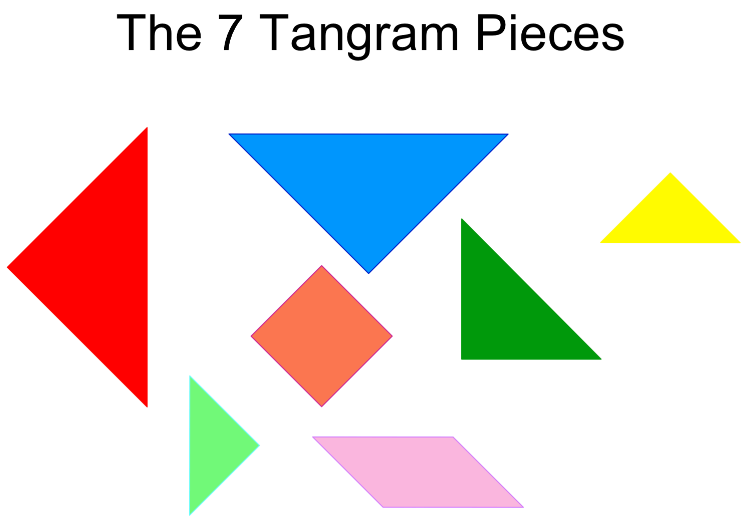

Figure E-2 The 7 tangram pieces used

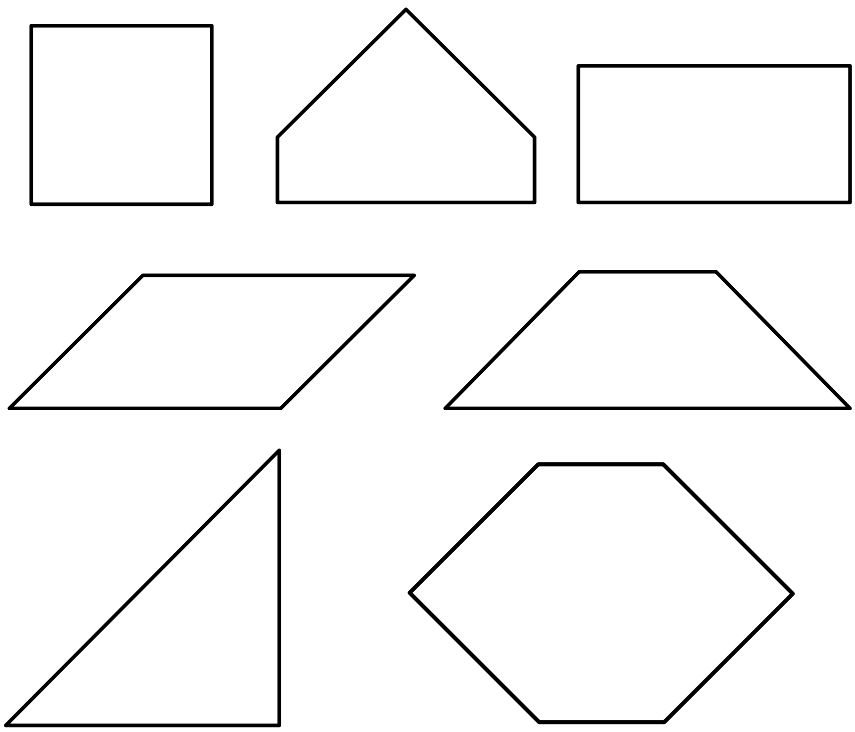

Figure E-3 The tangram activity for the challenge condition

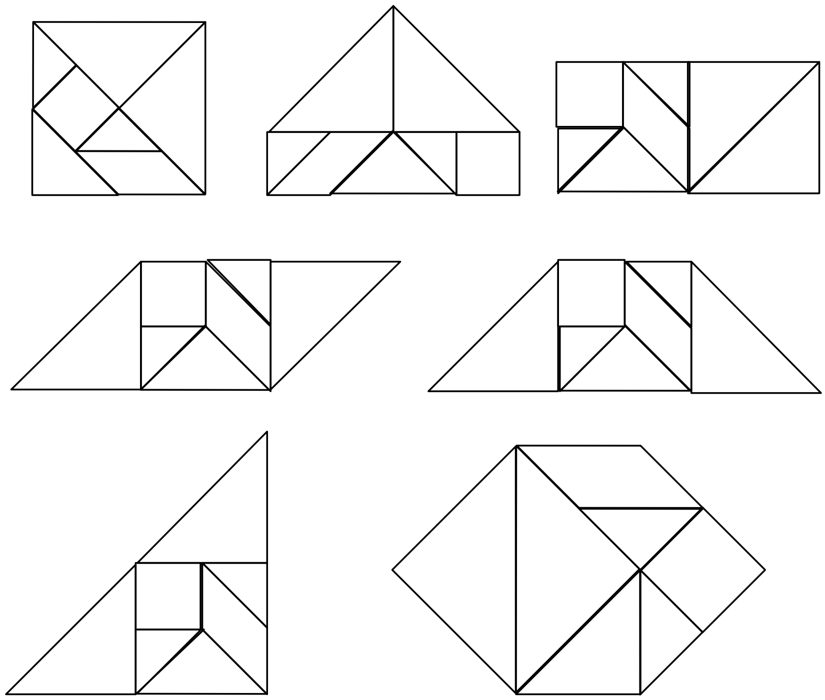

Figure E-4 The Tangram activity for the success condition

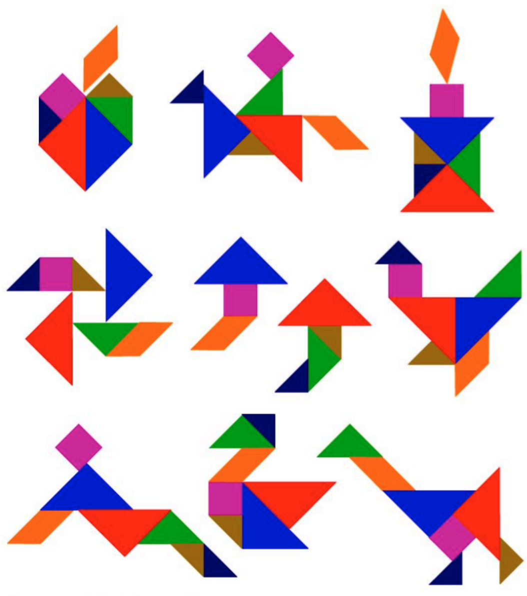

Figure E-5 The Tangram activity for the active control group

E.1.2 Behavioural Task: Puzzle Sets A and B

Puzzle Set A

Puzzle Set B

Puzzle Set A

Puzzle Set B

Puzzle Set A

Puzzle Set B

Puzzle Set A

Puzzle Set B

E.1.3 Photos of Control Group Tangram Patterns