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A quantitative study of the relationship between mindset and academic performance in first-year mathematics courses at the University of Cape Town

by

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ABSTRACT

Despite attempts to decrease university drop-out rates, the graduation rate remains low both internationally and locally. Internationally, up to 40% of students who enter higher education do not graduate; in South Africa, the number is higher at 55%. Several studies have found that growth mindset interventions help improve performance in mathematics and language courses. However, most of these studies are carried out outside of South Africa and on children and adolescents. Very little is known about whether and how the growth mindset theory can help improve performance in first-year university courses in South Africa. In this study, the correlation between mindset and performance in first-year mathematics courses is investigated.

First-year science, commerce, and engineering students (N=745) enrolled in four different introductory calculus courses participated in this study. Their mindsets were assessed using a survey questionnaire known as the Mindset Assessment Profile (MAP) tool. The reliability of the Mindset Assessment Profile was assessed using Cronbach's alpha coefficient. This was followed by a comparison of mindset scores of students enrolled in different degree programs. Moreover, the participants' average mindset scores in the current study were compared with international mindset scores. The participants' mathematics grades were collected for different assessments during the academic year. The changes in mathematics grades were compared with the mindset scores to examine the relationship between the two variables. The mathematics grade changes were used instead of the grades themselves; this is because the aim was to measure the improvement in mathematics grades rather than the final grade. In the face of failure, students with a growth mindset are predicted to put more effort and seek feedback to improve their grades in subsequent assessments.

On average, the participants of this study were growth mindset oriented according to the Mindset Assessment Profile tool. The MAP was moderately reliable, with Cronbach's alpha coefficients ranging between 0.501 and 0.642. Item-by-item analysis showed that reliability could not be improved by the removal of any item in the Mindset Assessment Profile. There was a significant difference between the mindset scores of commerce students and the mindset scores of science and engineering students. Students enrolled in commerce degree programs scored significantly lower than students enrolled in science and engineering degree programs on the MAP. The University of Cape Town students scored higher than Hong Kong university students on the mindset scale but lower than the students in the US. There was no statistically significant correlation between mindset scores and academic performance in any of the degree programs. The correlations were assessed for (a) all the students, (b) students who failed their first mathematics test, and (c) students who scored 75% and above for their first mathematics test.

The findings of this study provide a baseline of mindset scores for a South African university population. The tool for measuring mindset may need to be adapted to be better suited for the population outside of the United States. Furthermore, future research should investigate the effects of a growth mindset intervention on academic performance in mathematics grades at the University of Cape Town.

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CHAPTER ONE: INTRODUCTION

1.1. BACKGROUND

The high drop-out rate in higher education remains of great concern with a large number of publications dedicated to its mitigation. Approximately half of all drop-outs occur in the first year of studies (Willcoxson, 2010). According to Limeri et al. (2020), "students' academic success is influenced not only by their cognitive abilities and content knowledge, but also by non-cognitive factors, such as their beliefs, attitudes, and values."(p.1).

Recently, several researchers (e.g. Devers, 2015; Tirri & Kujala, 2016; Zeng et al., 2016; Bazelais et al., 2018; Limeri et al., 2020) investigated the effects of students' beliefs about the malleability of their intelligence on their academic performance. These beliefs are termed ***mindsets,*** which Dweck (2006) described as a self-perception or "self-theory" that students hold about their intellectual abilities. Students can vary in their beliefs, from more of a fixed mindset to more of a growth mindset (Yeager & Dweck, 2012). In a ***fixed mindset***, students believe that their basic qualities, like their intelligence, are fixed traits, whereas, in a ***growth mindset***, students believe that their abilities are malleable and can be developed through hard work and dedication. The term **implicit theories of intelligence** has been widely used to describe Dweck's mindset theory (e.g. Dweck & Leggett, 1988; Henderson & Dweck, 1990; Dweck & Sorich, 1999; Lüftenegger & Chen, 2017). There exist two extremes within the implicit theories of intelligence spectrum: entity theory (fixed mindset) and incremental theory (growth mindset). These extremes are on opposite ends of a continuum rather than binary states. Students usually do not hold beliefs that align fully with either extreme, instead, their beliefs at some time and particular circumstances can be mapped to the continuum (Dweck, 2016).

Although many researchers have reported that there is a direct correlation between growth mindset and academic success, some researchers have reached contradictory conclusions (e.g. Dommett et al., 2013; Rheinschmidt & Mendoza-Denton, 2014; Sisk et al., 2018). While most of the studies have investigated the relationship between mindset and academic achievement in primary and secondary schools, not much research has been done on how mindset influences academic achievement in universities. Moreover, the majority of these studies were conducted in American and European schools. Thus, this study investigates the relationship between mindset and academic achievement in undergraduate university students in South Africa.

1.2. PROBLEM STATEMENT

The failure rate in university mathematics courses remains high (Awaludin et al., 2015). Researchers have identified several factors that influence students' performance in the first-year of university. These factors include academic background (Van den Broeck et al., 2018), sense of belonging (Anderman & Freeman, 2004), teaching quality (Darling-Hammond, 2000), and prior knowledge from high school (Kizito, Munyakazi & Basuayi, 2016) among others. While literature indicates that a growth mindset can improve students' performance in primary and secondary schools, little research has been done on how mindsets affect students' performance in the first year of university, specifically in an African context. According to mindset theory, students with a fixed mindset may respond to failure by retreating, trying to hide the results, questioning if they

are the right type of person to be studying mathematics, while students with a growth mindset would use failure as feedback to direct their efforts to improve.

Most mindset research has been carried out in middle schools (typically grades six to eight) as this is thought to be a time of great transition for students. King et al. (2012), argue that it is during the transition to middle school that students focus on ability, self-assessment, social comparison, and competition. However, many students struggle with the transition between high school and university (Kajander & Lovric, 2005; Venezia & Jaeger, 2013). Mindset may thus play a role in first-year university students' performance, especially for students who excelled in high school and struggle at university.

1.3. PURPOSE OF THE STUDY

This research aims to get a better understanding of the mindsets of University of Cape Town first-year mathematics students, how this compares with mindsets of other post-secondary students around the world, as well as the relationship between mindset and academic performance. This will be achieved by completing the following objectives:

- Investigating the Mindset Assessment Profile tool's internal consistency to ensure that the students' mindset scores are measured reliably for the University of Cape Town population.
- Comparing the mindset scores of students enrolled in commerce, engineering, and science degree programs.
- Comparing mindset scores of South African university students with mindset scores of students in other universities around the world.
- Investigating the relationship between students' beliefs about the malleability of their intelligence and their academic performance.

This will be accomplished by (a) measuring students' mindset using the Mindset Assessment Profile (a 6-point Likert scale with eight items), (b) assessing students' mindsets through interviews, (c) collecting and analysing students' mathematics grades for different assessments, (d) assessing the reliability of the mindset scale, and (e) analysing the statistical correlation between mindset scores and mathematics grade changes. Cronbach's alpha coefficient will be used to measure the internal consistency of the Mindset Assessment Profile. Kendall's rank correlation coefficient will be used to determine if there is any correlation between mindset and academic performance.

1.4. RESEARCH QUESTIONS

Having discussed the focus and the purpose of the research, it is now appropriate to present the following research questions:

RQ1: Is the Mindset Assessment Profile a reliable measure of mindset for University of Cape Town first-year students studying mathematics?
RQ2: Is there a significant difference in students' mindset scores across different degree programs at the University of Cape Town?

RQ3: Is there a difference between mindset scores of first-year students at the University of Cape Town and post-secondary students in other countries?

RQ4: Is there a statistically significant correlation between mindset scores and academic performance in first-year mathematics courses at the University of Cape Town?

1.5. SIGNIFICANCE OF THE STUDY

This research may raise awareness about mindset theory among local lecturers and curriculum advisors, and guide those who wish to teach and promote a growth mindset among their students in order to improve the pass rate in first-year mathematics courses. Researchers have used growth mindset interventions to help students succeed academically; for instance, interventions to promote growth mindsets can effectively eliminate stereotype threat effects (Aronson et al., 2002; Good et al., 2003). This work could help initiate and direct growth mindset interventions to improve student engagement and potentially combat the high failure rate in mathematics at the University of Cape Town.

This research will contribute to the current body of research in several ways. Mainly, this is the first multi-course mindset study to be done on first-year mathematics students in Africa. The validity of the Mindset Assessment Profile (MAP) tool will be measured for the first time on University of Cape Town students. Depending on the validity of the scale, improvements may be made based on the results of this study. It will be a great contribution to the mindset research in South Africa to have the Mindset Assessment Profile tool validated. Furthermore, it would be useful to know the differences in mindsets of students enrolled in different degree programs i.e. science, engineering, and commerce. For instance, efforts to promote a growth mindset can be directed at a group of students that scored lower on the mindset scale.

1.6. NATURE OF THE STUDY

This research uses a correlational, descriptive, mixed-method approach to answer the research questions and reach the research objectives. The study is non-experimental. Mindset scores and mathematics grades are measured, and the statistical relationship between the two variables is assessed without manipulating, altering, or controlling the mindset of the participants.

Mindset scores were obtained from questionnaire responses by first-year students enrolled in four mathematics courses who volunteered to participate in the study. Some of the survey respondents were interviewed.

1.7. DEFINITIONS OF TERMS

Although these terms are described briefly in Chapter Two, they are presented here to help the reader make sense of the terms in the subsequent chapters.

Mindsets are perceptions or beliefs that people have about their intelligence, abilities, or competencies (Dweck, 2006).

A growth mindset is defined as a belief that intelligence is malleable and can be improved through learning and effort (Dweck, 2006).

A fixed mindset is a belief that intelligence is a fixed trait, and one is born with a certain amount of it (Dweck, 2006).

Mindset Assessment Profile, abbreviated MAP throughout the thesis, is a questionnaire used to assess participants' mindsets in this study.

The following are the course codes for different first-year mathematics courses offered at the University of Cape Town.

MAM1000W is for science and actuarial science students.
MAM1004F is for students enrolled in earth and life sciences degree programs.
MAM1010F is for commerce students.
MAM1020F is for engineering students.

1.8. OUTLINE OF THE CHAPTERS

This thesis is divided into five chapters.

Chapter 1 has provided the background of this study and its objectives and has placed it in the broad research of non-cognitive factors. The research questions and the significance of the study were discussed. The terms used in this study were defined.

Chapter 2 will provide a theoretical framework of the study by reviewing the current literature on mindsets and their effects on academic achievement.

Chapter 3 will describe the research methodology of the study and explain the rationale for selecting the methodology. Research design and procedures for the investigation will be discussed in detail.

Chapter 4 will present the results of the data analysis and provide both a written and graphic summary of the results.

In **Chapter 5,** the results will be interpreted and discussed, as they relate to the current literature.

1.9. PUBLISHED RESULTS

Some of the quantitative results that are discussed in this thesis have already been published in a peer-reviewed paper (Mokhithi, Campbell, & Shock, 2020). This thesis takes an expansive view of these results and includes qualitative data on top of the quantitative data that was discussed in the published work.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

This literature review aims to give an overview of existing literature related to mindsets and academic achievement. The first parts of the chapter give a brief overview of psychological measurements as well as definitions and a detailed comparison between fixed mindset and growth mindset. Next, different scales used to assess students' mindsets in literature are discussed. Finally, evidence about the relationship between mindset and academic achievement is presented as well as the possible mechanisms behind this. Themes, trends, and conflicts in the body of research relevant to the current study will be identified and discussed.

2.2. MEASURING THE MIND

Is it possible to accurately measure psychological attributes like intelligence, personality, ability, and attitudes? In the physical sciences, measurements of properties (such as temperature, mass, and volume) are supported by empirical evidence that demonstrates the quantitative nature of the property assessed (Salzberger, 2013). Salzberger further argues that measurements in social sciences are, "in large part, made possible only by a vague, discretionary definition of measurement that places hardly any restrictions on empirical data" (p.1). Researchers have attempted to measure psychological attributes since the late nineteenth century (e.g. Edgeworth, 1888, Baldwin, Cattell, & Jastrow, 1898, as cited in Sijtsma (2011)) and have since continued to improve the quality of psychological measurements. The instruments for measuring psychological attributes are called tests, scales (or questionnaires). Tests, scales, and questionnaires typically contain a list of questions or statements called items. In this study, participants' beliefs about their own intelligence are measured using such methods.

Measuring psychological attributes has benefits and drawbacks. Teachers need to test school children for dyslexia, some students take personality tests to decide which career will suit their personality, corporate companies use psychometric tests to recruit the best candidates for a job. However, concerns have been raised about the validity of the instruments for measuring psychological attributes. Lissitz (2009) asserts that validity is arguably the most fundamental and controversial issue in psychological measurements. The validity of psychological measurements can be threatened by participants avoiding or favouring answers that are in the most extreme rating-scale category (Greenleaf, 1992), or tending to answer in the middle category (Bishop, 1987). Other participants tend to give socially desirable responses (Lanyon and Carle, 2007) such as answers that are acceptable in social situations. For example, in response to the item "I like work that I'll learn from even if I make a lot of mistakes." a student who doesn't like work that is challenging may give a positive response to this item because they know it is accepted behaviour to want to learn from mistakes.

2.3. FIXED VS GROWTH MINDSET

Definitions and implications on behaviour

The belief that mathematical ability is something you either have or do not have is very common (Jonsson et al., 2012) and can have detrimental impacts on students' performance (Rattan, Good, & Dweck, 2012). Such a belief is in line with Dweck's (2006) **mindset theory** which conceptualizes that students' beliefs about their intelligence tend to fall along a spectrum, with each end representing how students view their intelligence, as either fixed or malleable (Dweck & Leggett, 1988). Students with a **growth mindset** believe that their abilities are malleable and can be improved with hard work and effort, while students with a **fixed mindset** believe that their basic qualities, like their intelligence or skills, are fixed (Dweck, 1999). Students' mindsets can be domain-specific (Yeager & Dweck, 2012); for instance, a student can have a fixed mindset towards mathematics but have a growth mindset towards another subject. While students with a fixed mindset might be as academically capable as those with a growth mindset, their behaviour in the face of failure may affect their academic achievements negatively (Tirri & Kujala, 2016). The paragraphs that follow make a comparison of how students with different mindsets respond to challenges, feedback, and effort-demanding work, as well as how they set achievement goals.

Students with a growth mindset tend to embrace challenges and see them as an opportunity to learn and improve their abilities; when work becomes more challenging, they put more effort in, change their strategy, and engage more (Ommundsen, 2003, as cited in Mokhithi, Campbell, & Shock (2020)). In such situations, they become more resilient and seek help. In contrast, students with a fixed mindset tend to avoid academic challenges; they prefer easier problems that will make them look and feel smart (Mueller & Dweck, 1998; Yeager et al., 2016, as cited in Bettinger et al., 2017). When they can't easily overcome a challenge, they become discouraged and disengaged. They avoid difficult challenges because they see failure as a sign that they are not "gifted" or "smart" enough. A stereotypical thought would be, "If I have to try hard at math, I'm not smart at math" (Blackwell et al., 2007).

Challenges fall under external environmental factors as students can't control when and how they come. Another external factor is feedback. Students with different mindsets tend to respond to the same feedback differently. Providing feedback is an integral part of teaching and learning and influences performance (Shute, 2008). However, students don't always appreciate criticism. Students with a growth mindset view criticism and negative feedback as a way to improve their abilities instead as an insult (Dweck, 1999). In contrast, students with a fixed mindset do not appreciate negative feedback and criticism. They may see it as a personal attack and have an emotional reaction to it. Since students with a fixed mindset believe that their abilities are fixed, they perceive criticism of their academic work as a criticism of their fixed intelligence. Students with fixed mindsets only appreciate feedback when it is positive and makes them feel smart.

In contrast with challenges and feedback, which are external environmental factors, there are also internal factors. Willingness to put effort into academic work is an example of an internal factor because students can control how much effort they put in. Students with different mindsets tend to view effort differently. For instance, since students with a fixed mindset believe that their intelligence is fixed, they may feel that putting a lot of effort into academic work is a waste of time since it would not change their ability. Miele and Molden (2010) observed a "tendency for [fixed

mindset] students to become less confident as they put more effort into the task" (p. 553) because they may see putting in the effort as a sign of not having the natural ability. In contrast, students with a growth mindset view effort as an essential aspect of learning that fuels intelligence.

Another internal factor is the goal orientation that a student tends to adopt. According to Meece, et al. (2006), "goal orientations refer to reasons or purposes for engaging in learning activities and explains students' different ways of approaching and responding to achievement situations" (as cited in Park (2018), p. 2). Students' differences in mindset manifest themselves through differences in the goal orientations they tend to adopt. There are two basic types of goal orientations, learning (or mastery) goal orientation, and performance goal orientation (see Dweck & Leggett, 1988). Students who adopt learning (mastery) goals focus on learning and developing their competence while students who adopt performance goals focus on demonstrating their competence to others (Dweck, 1986; Nicholls, 1984). Blackwell and colleagues (2007) found that students who held growth mindset beliefs significantly adopted learning goals and showed persistence in the face of challenges compared to students who held fixed mindset beliefs, who adopted performance goals and were more concerned about getting good grades and outperforming others. In addition to learning (mastery) and performance goals, performance goal orientation has been further distinguished into performance-approach and performance-avoidance goals (Elliot & Church, 1997, as cited in Park (2018)). When comparing the two sub-types of performance goals, Yu and McLellan (2019) reported that "students with performance-approach goals aim to demonstrate high academic competence to others, and those with performance-avoidance goals aim to avoid looking incompetent relative to others" (p. 3). Students with a fixed mindset are more likely to set performance-avoidance goals (Farrington & Levenstein, 2013; Farrington et al., 2012), this is because they tend to avoid challenges.

Some researchers have incorporated the same approach and avoidance distinction and introduced mastery-approach and mastery-avoidance goals (e.g. Elliot & McGregor, 2001), while other researchers have introduced task-involved and ego-involved goals, and task-focused and ability-focused goals (Maehr & Midgley, 1991; Nicholls, 1984, as cited in Park (2018)). The current study focuses on the two basic goal orientations: performance, and mastery goal orientations.

According to Dweck (2000), students with a fixed mindset tend to pursue performance goals; they tend to be more interested in demonstrating how smart they are and prefer tasks that will reassure them of their intelligence. For example, students with a fixed mindset who have adopted performance goals report that doing better than other students in school is important to them and would make them feel successful (Bråten & Strosmo, 2006; Chen & Pajares, 2010; Elliot & McGregor, 2001). Students with a growth mindset tend to pursue learning goals (Dweck et al., 1982) and tend to be more focused on mastering the material taught in class, and developing their abilities (Mellat & Lavasani, 2011).

In their meta-analysis, Burnette et al. (2013) found that although several researchers agree that, compared to students with a fixed mindset, students with a growth mindset are less likely to set performance goals and more likely to set learning goals (Robins & Pals, 2002; Mangels et al., 2006), other researchers reported weak correlations (Sarrazin et al., 1996; Maurer et al., 2002; Dupeyrat & Mariné, 2005) while other researchers found quite the opposite (e.g. Biddle et al., 2003). Regardless of the conflicts, it appears to be more beneficial for students to adopt learning

goals and focus on mastering the material taught in class, especially for a challenging course like first-year mathematics.

This subsection has described the differences between behaviours of students with different mindsets and suggests that it is beneficial for students to adopt a growth mindset. Students with a growth mindset tend to enjoy challenges, put more effort into their work, value feedback and are focused more on learning and mastering the material taught in class rather than focusing on demonstrating their competencies. However, teachers have been criticised for implementing growth mindset theory in classrooms by simply telling the students to have a "growth mindset" without understanding or addressing the underlying principles (Edwards et al., 2017). The following sub-section will discuss some common misconceptions about mindsets.

Common misconceptions of fixed and growth mindsets

One of the biggest misconceptions perpetuated by educators who don't fully understand the growth mindset theory is what Dweck (2016) referred to as a "false growth mindset". In a "false growth mindset" , students (especially the lower-achieving ones) are given empty praise for putting in effort when they have not succeeded, in the hope of developing a growth mindset. Growth mindset is not just about effort, but about using effective learning processes and strategies that lead to performance.

Another misconception is that mindset is binary (fixed mindset or growth mindset) and a fixed trait. Although students' mindsets have been treated as fixed in previous research (e.g. Doron et al., 2009; Chen & Pajares, 2010), it has been shown to be sensitive to environments (Dweck & Molden, 2005) and changeable (Dweck, 2012). Researchers have encouraged students to adopt a growth mindset using mindset interventions. Several experimental studies have manipulated students' mindsets in the desired direction using growth mindset interventions (e.g. Aronson et al., 2002; Blackwell et al., 2007; Burns & Isbell, 2007; Plaks & Stecher, 2007, as cited in Dai and Cromley (2014)). However, students' mindsets can also change in a non-intervention learning environment (e.g. Gonida et al., 2006; Shively & Ryan, 2013; Carr & Dweck, 2011). Dweck (2016) further clarified in her Harvard Business Review article that "a pure growth mindset does not exist, everyone is actually a mixture of fixed and growth mindsets and that mixture continually evolves with experience." (para. 4).

Lastly, a common misconception is that having a growth mindset levels the field. Blackwell, Trzesniewski, and Dweck (2007) stressed that "It is important to recognize that believing intelligence to be malleable does not imply that everyone has the same potential in every domain, or will learn everything with equal ease. Rather, it means that for any given individual, the intellectual ability can always be further developed" (p.247). This is especially important when there are systemic reasons for the underperformance of students, such as socioeconomic status, race, and language. South African students come from diverse backgrounds that lead to different reasons why some students are at risk of not successfully completing their first year at university. Conceptualising the growth mindset theory as a way of levelling the field would be unfair to some students who are at a disadvantage compared to students who have not had the same challenges. Several researchers have conducted studies to investigate why poorer South African students perform worse academically (e.g. Spaull, 2013; Mlachila & Moeletsi, 2019).

2.4. ASSESSMENT OF MINDSETS

There exist different versions of Dweck's (1999) scale for measuring mindset. Table 1 below presents Cronbach's alpha coefficients for different scales for studies conducted in various locations. Cronbach's alpha coefficients usually range between 0 and 1 but there is no lower limit. The closer the value of the coefficient to 1 to more reliable is the scale. In this subsection, different versions of the mindset scale and their reliability are discussed.

Table 1: Mindset scale versions and their reliability for different populations.

Author (year)	Sample size	Location	Size of scale	Type	Cronbach's alpha
Bahnik and Vranka (2017)	5 653	A university in the Czech Republic	Two items on a seven-point Likert scale	General, translated to Czech	Not reported
Burgoyne, Hambrick and Macnamara (2020)	438	Two universities in the USA	Eight items on a six-point Likert scale	General	0.92
Chen and Wong (2014)	312	A university in Hong Kong	Six items on a six-point Likert scale	General, translated to Mandarin	0.95
Chen and Wong (2015)	418	A university in Hong Kong	Five items on a six-point Likert scale	General, translated to Mandarin	0.90
Dai and Cromley (2014)	330	An urban, mid-Atlantic university in the USA	Eight items on a six-point Likert scale	Domain-specific - biology	0.73
Glerum, Loyens and Rikers (2020)	1 005	A vocational school in the Netherlands	Six items on a six-point Likert scale	General, translated to Dutch	0.74

Gunderson et al. (2017)	190	A large public university in the USA	Four items on a six-point Likert scale	Domain-specific – mathematics, reading, and writing	Not reported
Ingebrigtsen (2018)	544	Schools and colleges in Norway	Six items on a six-point Likert scale	General, translated to Norwegian	Not reported
Shively and Ryan (2013)	159	Mid-western University in the USA	Eight items on a seven-point Likert scale	Domain-specific - mathematics	Not reported
Tempelaar et al. (2015)	4 594	A university in the Netherlands	Eight items on a six-point Likert scale	General, translated to Dutch	0.90

The studies in Table 1 were selected to include a variety of mindset scales used in studies conducted on post-secondary students with high sample sizes. It is interesting to see that there is a wide range of scales used to measure mindsets. Some differ in the number of items, some are translated to different languages, some are domain-specific, while some assess how students see their own intelligence as opposed to intelligence in general. Indeed, some scales are more appropriate for a specific location or age group and this makes it difficult to compare the studies. Especially when some scales have been shown to be more reliable than others, this can lead to incorrect conclusions about mindset correlations (e.g. correlations between growth mindset and academic performance) and the effectiveness of a mindset intervention, for example. Apart from a recent article by Burgoyne and Macnamara (2020), little has been written about the comparison of different scales, indicating an area for further research. The studies conducted in universities are the most relevant for comparison with the current study, specifically studies that assess mindset in general using the most popular eight-item, six-point Likert scale.

The choice of the measure for mindset is crucial. In their meta-analytic review, Costa and Faria (2018) reported that ten studies that used specific Implicit Theories of Intelligence measures to assess participants' mindsets in specific domains found that the correlation between mindset and academic performance is affected by the type of mindset measurement. Specifically, they found that domain-specific scales showed a stronger correlation between mindset and academic performance.

A domain-specific mindset scale is one that measures students' beliefs about their abilities in a specific subject rather than about intelligence in general. Dai and Cromley (2014) conducted a one-year longitudinal study to investigate the relationship between changes in students' beliefs about their abilities in biology and the drop-out rate. They adapted the scale to be specific to the

biology domain since their participants were biology students; an example of an item in the scale is "My ability in biology is something that I can't change very much". Gunderson and colleagues (2017) adapted the scale to two domains, mathematics and writing, while Shively and Ryan (2013) assessed mindset with respect to "overall intelligence". Cronbach's alpha coefficients for these studies are shown in Table 1. The scale used in the current study (i.e. the MAP) contains statements about intelligence in general.

Apart from making the Theories of Intelligence Scale specific to a domain, the scale has been translated to different languages. Chen and Wong (2014, 2015) set out to investigate the relationship between mindset and goal orientation and their joint effect on academic performance on university students in Hong Kong. They translated the Theories of Intelligence scale from English to Mandarin and termed it "Chinese mindsets". The translated scale had high internal consistency as indicated by a high Cronbach's alpha coefficient of 0.90. Ingebrigtsen (2018) translated the mindset scale from English to Norwegian (termed the novel Norwegian Growth Mindset Scale) and studied its reliability on 554 Norwegian students. The psychometric properties of the scale were assessed using Confirmatory Factor Analysis and Item Response Theory and the scale was found to be reliable.

Another version of the Theories of Intelligence scale is the self-theory scale. In this scale, the statements in the original scale are reworded to reflect a first-person claim about the extent to which they believe the malleability of intelligence. For example, the statement "You have a certain amount of intelligence, and you really can't do much to change it" is reworded to "I have a certain amount of intelligence, and I really can't do much to change it". De Castella and Byrne (2015) examined whether students' beliefs about their own intelligence differed from their beliefs about intelligence in general. They concluded that students endorsed a fixed mindset less when asked about whether they believed that their personal intelligence can be developed compared to when they are asked about whether general intelligence can be developed. Furthermore, they found that students' beliefs about the malleability of their own intelligence are a better predictor of achievement than their beliefs about intelligence in general. Interestingly, they found that Cronbach's alpha coefficient for the self-theory scale ($\alpha = 0.90$) was higher than the one for the general Theories of Intelligence scale ($\alpha = 0.87$). The current study uses a scale that has statements about intelligence in general. To improve the reliability of the mindset scale for future research, the self-theory scale should be used.

Making comparisons between mindset studies is complicated by the inconsistent use of scale items and the different versions of the mindset scales developed by Dweck and other researchers. Some studies (e.g. Thiele, 2016; Cartwright & Hallar, 2018) refer to the Theories of Intelligence scale (Dweck, 2006) but in fact use items from the Mindset Assessment Profile Toolkit (Mindset Works, 2012). This inconsistency does not seem to be addressed in the literature.

2.5. MINDSETS AND ACADEMIC ACHIEVEMENT

How mindset affects academic achievement

Students' mindsets can influence other non-cognitive factors that have been shown to affect achievement. Specifically, mindset can help reduce the effects of stereotype threat (Aronson & Good, 2003), influences goal-orientation (Mueller & Dweck, 1998), impacts motivation (Yeager et al., 2016), and can also influence students' attribution theory (Song, Kim, & Bong, 2020), and self-efficacy (Zimmerman, 2000).

Mindset has been shown to mitigate the effects of stereotype threat. Steele (2003) defined **stereotype threat** as "the threat of being viewed through the lens of a negative stereotype, or the fear of doing something that would inadvertently confirm that negative stereotype" (p. 109). Stereotype threat may have negative effects on students who belong to a stereotyped group (e.g. black students, women studying STEM majors, and students with learning disabilities). Evidence of these effects has been reported in the literature. For instance, Steele and Aronson (1995) found that African-American students who were asked to indicate their race on a test answer sheet performed significantly lower than a control group who did not report their race. Growth mindset interventions have been implemented to reduce the effects of stereotype threat on women (enrolled in STEM majors) and black students (see Steele & Aronson, 1995; Aronson et al., 1999; Spencer, Steele, & Quinn, 1999; Steele, 2002; Good, Aronson, & Inzlicht, 2003; Shih, Pittinsky, & Trahan, 2006; Beasley & Fischer, 2012; Good, Rattan, & Dweck, 2012).

As discussed in the preceding section (see section 2.2), students' mindsets influence their goal orientation and consequently influence their academic performance.

Mindsets influence motivation. According to Schunk and colleagues (2008), academic motivation "refers to the cause of behaviours that are in some way related to academic functioning and success, such as how much effort students put forth, how effectively they regulate their work, which endeavors they choose to pursue, and how persistent they are when faced with obstacles" (as cited in Usher and Morris, 2012, p. 2). Motivation is critical for academic achievement in all students (Christensen et al. , 2008, as cited in Rhew et al., 2018). Mindset influences students' motivation; for instance, Dweck (2006) reported that students with a fixed mindset eventually develop "low effort syndrome" (p. 58). Students with the low-effort syndrome have low motivation to learn and avoid challenging tasks (and potential failure) to protect their egos. In contrast, students with a growth mindset are motivated to put more effort when work becomes more challenging (Dweck, 2006). High motivation has been associated with academic success (Hodis et al., 2011) and academic competence (Linnenbrink & Pintrich, 2002). In the current study, students' mindsets are hypothesized to influence students' motivation and ultimately influence their academic performance.

Students who hold different mindsets tend to attribute their failures and successes to different factors. Students tend to have a causal explanation for their successes and failures (Usher & Morris, 2012). According to Bandura (1997), "people who credit their successes to personal capabilities and their failures to insufficient effort will undertake difficult tasks and persist in the face of failure. They do this because they see their outcomes as influenceable by how much effort they expend. In contrast, those who ascribe their failures to deficiencies in ability and their successes to situational factors will display low strivings and give up readily when they encounter difficulties"

(p.123). As discussed earlier, students with a fixed mindset tend to attribute their failures to their fixed and limited abilities while students with a growth mindset tend to attribute their failures to lack of effort. If this is the case, we expect students (in the face of failure) with a growth mindset to attribute their failures to lack of effort, and in turn, put more effort and to seek help and consequently improve their academic performance compared to fixed mindset oriented students. Although students with a fixed mindset may realise that they didn't put enough effort, they may still not want to try harder even if they think it would help because deep down they believe that putting in the effort is only for those with low ability and they do not want to be labelled 'low ability.'

A number of studies have looked at self-efficacy in various different ways. Bong and Skaalvik (2003) described self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 5). Previous research has studied the effects of mindset on self-efficacy. Baldridge (2010) examined the effects of a growth mindset intervention on the academic self-efficacy (among other beliefs) of students with reading difficulties. She found that a growth mindset improves a student's academic self-efficacy. Self-efficacy, in turn, correlates with students' outcomes, including but not limited to performance and academic aspirations (Bong & Skaalvik, 2003). Furthermore, Bandura (1997) argues that "efficacy beliefs influence the level of effort, persistence, and choice of activities. Students with a high sense of efficacy for accomplishing an educational task will participate more readily, work harder, and persist longer when they encounter difficulties than those who doubt their capabilities" (p. 129). Several other studies agree with Bandura (e.g. Schunk, 1981; Schunk, 1989; Usher & Pajares, 2008a). Moreover, in studies that replicated research from different domains, it was found that science students with high self-efficacy outperformed their counterparts who had a lower sense of self-efficacy (Britner & Pajares, 2006; Usher & Pajares, 2008b). In the current study, students with a growth mindset are expected to have a high sense of self-efficacy, and therefore show better academic performance.

Evidence of the relationship between mindsets and academic achievement

Several researchers have found a positive correlation between a growth mindset and academic achievement after interventions (e.g. Yeager et al., 2019; Yeager & Walton, 2011). For instance, in an effort to reduce **stereotype threat**, Aronson, Fried, & Good (2002) encouraged African American Stanford University undergraduate students (N=109) to view intelligence as malleable by having them teach high school students about the plasticity of the brain. Blackwell, Trzesniewski, and Dweck (2007) found that seventh graders at a public school in New York City achieved higher mathematics grades than a control group after teaching students to think of their intelligence as malleable. This five-year study investigated the effects of mindset amongst other motivational variables. The instrument used measured mindsets and other achievement-related beliefs.

Yeager and colleagues (2014) conducted a similar study on ninth-grade high school students in Northern California and found that students with a growth mindset achieved higher grades after a mindset intervention. They investigated the effects of mindsets on health, stress, and academic achievement. As a preface to the intervention, teachers gave an overview of how the brain changes and learns. The experimental intervention employed a 'saying-is-believing' approach by getting the

participants to write their own versions of what was presented to them about the malleability of their personality traits.

Most of the mindset interventions were carried out on a small scale and in-person in one school at a time. Paunesku and colleagues (2015) sought to investigate whether the mindset intervention approach could be a practical way to raise school achievement on a large scale in their study. As such, they developed an online growth mindset intervention aimed at 1 594 students at risk of dropping out in 13 geographically diverse high schools in America. They found that students' grades in mathematics and English increased by 6.4 percentage points after the intervention.

There are also correlational studies that found a positive relationship between mindset and achievement in absence of a mindset intervention. Romero et al. (2014) found that middle school adolescents (at a suburban public school in America) who believed intelligence could be developed improved their grades over a school year. The researchers also measured the participants' mothers' education and used a three-item Theories of Intelligence Scale to measure mindsets. The student's theories of emotions were also measured.

Claro and her colleagues (2016) used a nationwide sample of high school students from Chile to investigate how mindset and socio-economic factors interact on a systemic level to influence academic achievement. Their findings suggested that students' mindsets may mitigate the effects of economic disadvantage on a systematic level. In the current project, growth mindsets are expected to influence academic achievement positively.

In spite of the above studies, several researchers have reported contradictory findings about the relationship between growth mindset and academic achievement. For instance, Dommett and colleagues (2013) delivered workshops on neuroscience teaching to 11-12-year-old pupils (N=383) in five schools in England about neuroplasticity in order to encourage them to adopt a growth mindset. They assessed several motivational measures including mathematics ability over a 20 month period but found no specific effects of growth mindset on mathematics performance.
Sisk and colleagues (2018) conducted two meta-analyses in a large number of students, the first meta-analysis (N=365,915) examined the strength of the relationship between growth mindset and academic achievement and potential moderating factors while the second meta-analysis (N=57,155) examined the effectiveness of growth mindset intervention on academic achievement and potential moderating factors. They found the overall effects to be positive but weak in both the meta-analyses.

Bahnik and Vranka (2017) measured the mindsets of university applicants (N=5,653) in the Czech Republic and found no positive association between mindset scores and test results. They used a Czech translation of the mindset scale with two items on a 7-Lickert scale. The translations of the mindset scale have raised concerns about reliability, and the small number of items may lead to an invalid scale. Cronbach's alpha coefficient for the scale in the study was not reported, which raises concerns about the reliability of the instrument used.

Bazelais and colleagues (2018) conducted a correlational study (N=309) to investigate the relationship between mindset, grit, and academic achievement among pre-university science

students enrolled in Canada. They reported that mindset is not predictive of academic performance for college-level students.

Li and Bates (2017) conducted three large studies in the absence of a mindset intervention on 10-12 year old students (N=624) to investigate whether there is a relationship between mindset and academic performance. They found no correlation between mindset and academic performance.
Glerum and colleagues (2020) aimed to investigate whether an online intervention was effective in secondary vocational education and training. The study (N=153) was conducted at four different vocational programs at a school for Adult and Secondary Vocational Education and Training (VET) in the Netherlands. After a 10-week online mindset intervention, they found that students who participated in the intervention did not score significantly higher than their counterparts in the control group. The mindset scale consisted of six mindset items. Furthermore, the mindset scale was translated to Dutch and showed a reasonably high reliability (Cronbach's alpha coefficient of 0.74).

A recent study, conducted by Burgoyne, Hambrick, and Macnamara (2020), involving 438 undergraduate students at two American universities, concluded that, after poor performance in a test, students with fixed mindsets actually performed better in a subsequent test. They further argue that "bold claims about mindset appear to be overstated" (p. 258).

2.6. SUMMARY

Having a growth mindset has been associated with positive academic behaviours by a number of researchers. As such, mindsets have piqued the interest of teachers and curriculum developers alike. Mindsets are worth investigating for South African university students as they may help lower the high failure rate in first-year university mathematics.

Although many researchers have found that a growth mindset is linked to improved academic performance, some studies have found conflicting evidence. For instance, Burgoyne, Hambrick and Macnamara (2020) claimed that the foundations of mindset theories are not firm and further suggested that claims about mindsets are bold and overstated. Of great concern is the lack of consistency in the scales used to measure mindset, as the type of scale used can affect the results of the correlations (Costa & Faria, 2018). The inconsistency in the use of scales is not the only concern about mindset studies, there seems to be a lack of statistical data (e.g. Cronbach's alpha for scales, p-values, and correlation coefficients) in the results reported in some studies. Moreover, researchers have raised concerns about the lack of data on the generalisability of the mindset scale (Onwuegbuzie et al., 2007). Although some studies have studied mindset in the South African context (e.g. Porter et al., 2020, Campbell, 2019), there appear to be none that investigate whether mindsets have an impact on academic achievement in South African universities. In this study, the relationship between mindset and academic performance is investigated in a South African population.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1. INTRODUCTION

The purpose of this chapter is to give a detailed account of the research methods and the methodology implemented in this study. The chapter will begin by explaining the choice of the research design, then the research methods. This will be followed by the discussion of the population and sample selection, instrument for data collection, and the data analysis methods which have been used. The chapter will conclude with a brief discussion of ethical considerations.

3.2. RESEARCH DESIGN

In order to satisfy the objectives of the study, a largely quantitative approach was used, complemented by a qualitative approach. Hence, this study employed a mixed methods design. Johnson et al. (2007) referred to mixed methods research as "the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purposes of breadth and depth of understanding and corroboration" (p. 123). Creswell and Plano Clark (2017) did not view mixed methods simply as methods, but rather as an approach to inquiry where the researcher combines both quantitative and qualitative data to obtain a consolidated understanding of a research problem. In the current study, both quantitative data and qualitative data were collected and analysed separately, and then integrated.

The first and largest part of this study consisted of measuring participants' mindsets using a well-structured online questionnaire. The other design used is a series of one-on-one interviews with a small number of students whose mindset scores were outliers. Mindset scores and mathematics test grades were measured and the statistical relationship between them was assessed without any interventions aimed at developing growth mindsets. Hence, this study employs a non-experimental design using a correlational approach.

3.3. RESEARCH METHODS

The Mindset Assessment Profile (Mindset Works, Inc., 2012), which is a questionnaire consisting of eight items on a six-point Likert scale, was used to measure students' mindsets. Questionnaires are a quick and reliable method to collect data from multiple respondents in an efficient and timely manner; this is especially important when it comes to a time-constrained project (Bell, 2005; Silverman, 2004). This study had a time constraint and the potential number of respondents totalled over two thousand (see succeeding section for details). Upon realising that most of the participants scored high on the MAP, follow-up interviews were conducted with students who scored the lowest to see if they will corroborate their questionnaire responses, and hence test the validity of the MAP. These follow-up interviews were conducted with a small number of students (N=18). During the interviews, the students were asked about how they viewed intelligence. The interview questions can be found in the Appendix. The internal reliability of the questionnaire was assessed using Cronbach's alpha coefficient.

3.4. POPULATION

The study population consisted of all first-year students enrolled in four mainstream mathematics courses in 2018 at the University of Cape Town. First-year mathematics was chosen for this study because of the stigma of mathematics being difficult; the students accepted to do first-year mathematics courses at the University of Cape Town were high achievers in high school mathematics and possibly achieved high grades in high school mathematics without being challenged. Many of these students fail mathematics for the first time in their first year of university. Hence, students' mindsets may play a role in how students react to failure.

The mathematics courses were MAM1000W, a whole year course designed for students enrolled in science and actuarial science degrees, MAM1004F, for students majoring in Life and Earth sciences, MAM1010F, taken by students majoring in commerce degrees (i.e. accounting, economics, finance, and tax) and MAM1020F, offered to engineering students. The total numbers of students enrolled in MAM1000W, MAM1004F, MAM1010F, and MAM1020F were 723, 315, 747, and 628 respectively.

3.5. PROCEDURES

The course convenors of the four courses were asked for permission to conduct the study. Once permission was granted, the course convenors were asked to notify their students about the learning questionnaire. The course convenors sent a message to their students in the form of an announcement (see appendix) on a learning management system used by lecturers as a primary mode of communication with their students (i.e. Vula). The announcement contained a link to the questionnaire that was uploaded on WebAssign, an online homework platform used by students for online mathematics assignments. Students were encouraged (they were informed that their input will help lecturers find more effective ways to support them) to take part in the learning questionnaire and gave consent for the results of the questionnaire to be used in this study. They were given a week to complete the questionnaire; at the end of the week, the students' responses were downloaded and exported to an Excel spreadsheet. There was an incentive (in the form of bonus marks) for MAM1000W students to complete the mindset questionnaire.

After it was found that the majority of the participants had a growth mindset, participants who had the most fixed mindsets were interviewed to assess if there were any discrepancies between their scores and their personal beliefs about intelligence. The students were unaware that their mindset scores were outliers. Following ethical clearance and permission to access students, short one-on-one interviews were conducted during the students' tutorials in the tutorial venues by the author and one of the supervisors of this study. During the interviews, the students were asked to describe behaviours of two different students, a successful student and an unsuccessful student. They were also asked to describe how their approach has changed since coming to university. Some of the questions required the students to share their thoughts about why students' performance drop in university and whether students who got academically excluded could graduate and what changes they would have to make. In the final and main question of the interview, students were asked whether they believe a person's academic ability is a fixed trait or not. Their responses to the main question were analysed and compare with their mindset scores in the MAP. The interview questions are in the appendix.

3.6. INSTRUMENT USED

As stated earlier, the Mindset Assessment Profile (MAP) scale, developed by Mindset Works, Inc. (2012), was used to measure the students' mindsets. The MAP scale was endorsed by Carol Dweck (Frary, 2018) and is expanded upon her eight-item Implicit Theories of Intelligence Questionnaire (Dweck, 2000) which measures growth mindset and the extent to which an individual believes that their intelligence can be improved. A copy of the questionnaire can be found in the Appendix. This scale consists of eight statements, four indicative of a growth mindset, and four indicative of a fixed mindset. Examples of such statements are "You can always substantially change how intelligent you are." and "You have a certain amount of intelligence, and you can't really do much to change it.". Students were asked to rate these statements on a 6 point Likert scale (1 = Disagree a Lot to 6 = Agree a Lot). The fixed mindset statements were reverse scored and the scores for each statement were added. Weighted scores range from 8 to 48, with scores of 24 and below indicating fixed mindsets and scores of 32 and above indicating growth mindsets (Dweck, Chiu, & Hong, 1995).

The eight-item Implicit Theories of Intelligence Scale (Dweck, 2000) upon which the MAP is based, began with only three fixed mindset items. During that time, Dweck et al. (1995) argued that only three items were needed because “implicit theory is a construct with a simple unitary theme, and repeatedly rephrasing the same idea may lead to confusion and boredom on the part of the respondents” (p. 269). However, a few years later, Levy et al. (1998) added one additional fixed mindset item and four growth mindset items. The researchers were concerned about the original format on whether disagreement with the fixed mindset items can be taken as agreement with the belief that traits (e.g. intelligence) are malleable. This eight-item version of the Implicit Theory of Intelligence Scale became widely used, especially after it was included in Dweck’s book in 1999.

The participants' mathematics grades for assessments written during the academic year were collected from the course conveners of the relevant courses. The assessment for commerce and engineering degree programs required written answers while the science degree program assessments were a combination of written answers and multiple-choice questions.

3.7. DATA ANALYSIS PROCEDURES

The results of the survey were downloaded as Excel spreadsheets. The data was then cleaned, making sure to (a) remove students who completed the survey but chose not to participate in the study, (b) remove any duplicates and incomplete entries, and (c) convert the participants' responses to numbers that could be analysed. The data were then analysed using IBM SPSS Statistics (version 26) predictive analytics software.

The reliability of the Mindset Assessment Profile was assessed using Cronbach's alpha coefficient. Cronbach’s alpha measures how closely related the items on a scale are as a group, this is also known as the internal consistency of a scale. The variables needed to calculate Cronbach’s alpha are: (a) the number of items on the scale, (b) the average inter-item covariance among the items, and (c) the average variance of each item. Normally, Cronbach’s alpha reliability coefficient ranges between 0 and 1 (the closer to 1 the more reliable the scale is) but there is no lower limit to

the coefficient. In addition to the MAP data, follow-up interviews were conducted with students whose scores were indicative of a fixed mindset. These students were asked questions relating to their beliefs about how they viewed their own intelligence. Their interview responses were compared with their questionnaire responses to assess the validity of the MAP.

The participants of this study came from four different first-year mathematics courses at the University of Cape Town. One of this study's objectives was to determine whether students' mindset scores differ with the degree programs they are enrolled in. If there are differences in the mindsets between students in different degree programs, there may be a need for different strategies to develop growth mindsets for students from different faculties. The Kruskal-Wallis test was conducted to determine whether there were significant differences in mindset scores amongst the four courses. However, the Kruskal-Wallis test only tells whether there is a significant difference or not, it doesn't tell where the difference lies. Traditionally, an independent sample t-test would be conducted to determine where the differences lie, which assumes that the data is both normally distributed and nominal. The data in this study was ordinal, thus the Mann-Whitney U Test was used for this purpose (Nachar, 2008). All the statistical tests were done on IBM SPSS Statistics.

Another objective of this study was to compare mindset scores of first-year mathematics students with those of students outside South Africa. Comparing mindset scores is difficult considering that researchers use different scales that have different numbers of items. For ease of comparison, the mindset scores were converted to percentages using a formula developed by Campbell et al. (2021).

Finally, the relationship between mindset and academic performance was assessed using a correlation test. There exist two main types of correlation coefficients: Pearson's correlation coefficient and Kendall's rank correlation coefficient (Mukaka, 2012). Kendall's rank correlation coefficient was used for this study because its assumptions aligned with the current study, i.e. data is ordinally measured on a Likert-scale. The correlations were tested for three groups of students: (a) all the participants, (b) participants who failed the first class test, and (c) participants who scored 75% or more in their first class test.

3.8. ETHICAL CONSIDERATION

Ethical clearance was obtained from the Research Ethics Committee of the Centre for Higher Education Development, University of Cape Town. Participants gave permission for their responses to be used for research by responding to a Yes/No question at the start of the online questionnaire. The participants were informed that participation was voluntary and that non-participation in this study would not affect their grades in any way. Participants were assured that outside the course and researchers, their responses would only be shared anonymously. Data was stored in password-protected computers and after the research was complete, anonymized datasets would be made available on an open-source repository at the University of Cape Town.

For the follow-up interviews, audio recordings were made, with the student's permission. The recordings were stored in password-protected devices and were not shared beyond the researchers.

CHAPTER FOUR: PRESENTATION AND ANALYSIS OF DATA

4.1. INTRODUCTION

Chapter Three provided detailed descriptions of the research design, the instrument used, the population, data collection procedures, and statistical tests employed. This chapter will provide an overview of the results of the statistical analyses of the data in relation to the overarching research questions posed in this thesis:

1. Is the Mindset Assessment Profile a reliable measure of mindset for University of Cape Town students first-year students studying mathematics?

2. Is there a significant difference in mindset scores across different degree programs at the University of Cape Town?

3. Is there a difference between mindset scores of first-year mathematics students at the University of Cape Town and post-secondary students in other countries?

4. Is there a statistically significant correlation between mindset scores and academic performance in first-year mathematics courses at the University of Cape Town?

The statistical relationship between mindset scores and changes in mathematics grades was assessed for three groups of students.

A. All the students.
B. Students who failed the first class test.
C. Students who achieved 75% or more in their first test.

Mindset questionnaires, interviews, first-year mathematics grades, and statistical analyses were used to address these questions. This chapter outlines the findings of the mindset survey and statistical analyses.

4.2. RESPONSE RATES

Students enrolled in four large first-year mathematics courses (N=745) participated in this study. The response rates are shown in table 2:

Table 2: Response rates for the mindset questionnaire.

	Number of students enrolled	**Number of students who completed the questionnaire**	**Number of responses used in the study**	**The response rate based on the number of responses used in the study**
MAM1000W	723	245	241	33.3%
MAM1004F	315	34	32	10.2%
MAM1010F	747	343	301	40.3%
MAM1020F	628	181	171	27.2%

The overall response rate was 30.9%. Sekaran & Bougie (2010) proposed that a response rate of more than 30% is acceptable while Saunders et al. (2009) asserted that a response rate of 20% is acceptable and encouraged researchers not to be discouraged by low response rates. The responses were assumed to be representative of the population.

4.3. IS THE MAP A RELIABLE MEASURE OF MINDSET FOR UCT FIRST-YEAR STUDENTS STUDYING MATHEMATICS?

Although the Mindset Assessment Profile (Mindset Works, Inc., 2012) is widely used, it is important to test its reliability for the South African population. Cronbach's alpha, one of the most commonly used indicators of reliability of Likert scales, was used to answer the first research question: *Is the Mindset Assessment Profile a reliable measure of mindset for University of Cape Town first-year students studying mathematics?*

Table 3 reports Cronbach's alpha values for each of the four groups of students.

Table 3: Cronbach's alpha coefficients for different subgroups of the sample.

	Cronbach's alpha α	Sample size n
MAM1000W	0.586	241
MAM1004F	-0.432	32
MAM1010F	0.581	301
MAM1020F	0.642	171

Overall	0.484	745
Overall excluding MAM1004F	0.501	713

Cronbach's alpha value for the MAM1004F group is negative, which implies that the mindset scale is not reliable for this group. It is for this reason that the data for the MAM1004F is omitted from the results that follow. The poor Cronbach's alpha value for MAM1004F could have been caused by a very small number of participants, i.e., 32 out of a class of 315 students.

Cronbach's alpha correlation values may be improved by reducing the number of survey items. Specifically, the items that reduce Cronbach's alpha coefficient can be removed.

Table 4 shows the percentage change in Cronbach's alpha coefficient if an item was removed from the scale.

Table 4: Cronbach's alpha coefficient percentage changes if an item is removed from the scale.

Item removed	**MAM1000W**	**MAM1010F**	**MAM1020F**
1	-3.07	+2.41	-2.02
3	-0.01	-0.01	-0.01
5	-7.04	-6.55	-5.56
7	-10.5	-13.9	-13.4
2*	+4.21	-3.14	-3.79
4*	-15.8	-9.90	-9.38
6*	-5.25	-2.30	+0.16
8*	+1.00	-0.19	+2.55

* Items that were reverse scored.

The purpose of the comparison in Table 4 was to see if there are any items that can be removed to improve the mindset questionnaire scale for all three courses. An item with a positive percentage change in all three courses could be removed from the scale in order to improve it. There are no such items.

Further to the Mindset Assessment Profile online questionnaire responses, students who scored low (indicative of fixed mindset) on the questionnaire were interviewed to assess whether their interview responses would corroborate their questionnaire responses or not. These students were outliers since most students' questionnaire responses were indicative of a growth mindset. During the interviews, the students gave responses indicative of a growth mindset contrary to their questionnaire responses. The poor correlation between mindset scores and interview responses

indicates that the MAP may not be valid for the University of Cape Town population. For instance, when student A was asked if he thought academic ability was a fixed trait, he responded:

> Oh no, no. Because at primary school I was not this brilliant, I mean I am not brilliant, but I was academically weaker and got through it through hard work, the help of my teachers, and my friends. Learning is a process from womb to tomb, so we can achieve more. It's not like a fixed point that you can't go beyond. If you put your mind to it, obviously you can achieve it.

Student B responded similarly:

> It is definitely not fixed at all, I do not believe that. We have the ability to learn, so that alone tells you that it is something that is not fixed. We can learn, we can develop our skills, it's not like you get 4 gigs of memory and that's it.

Student C also made comments indicative of a growth mindset:

> I think it can change, I think it is really about the amount of effort that you put in. Let's say maybe you do not understand polynomial division, there is a big difference between you saying "Okay, I don't understand this." and actually putting in the effort to try and understand it. It really can be changed, it's about the amount of effort and commitment that people are willing to put in to change it.

While student D gave mixed comments:

> I think genetics and the environment play a large role. Okay, I feel like if you have very clever and successful parents, genetically you have that natural ability. You know, when people naturally take the concepts quicker and pick up things quicker than other people. But it doesn't mean that a person who can't pick it up as quickly as the other person cannot work and get to the same level. Someone may get to the end of the test quicker than someone else, but they can still get the same mark at the end. I think that to an extent, it is either you are intelligent or not. But there are other influences - maybe the school you went to or your home environment, your parents' parenting style - also influence your work ethic. But just because your parents are not successful, or you didn't go to a private school and get a world-class education, I don't see why you can't achieve because you can still put in the work to achieve; but you may just have to put in more work than someone else whose had the other background.

Student D further said:

> Like I was saying, someone may be able to get to the end of the test quicker because of all the privileges or advantages they have compared to someone else who doesn't but in the end, even if it may take the other person longer, they can still get the same mark, they can still achieve the same thing. It may just take more work or more time than someone who is naturally intelligent. Your academic ability is something you can change to an extent. For example, if you are someone who is not math-oriented and prefer more linguistics, your

ability in math is just not something that clicks with you. You get people who are naturally good at math and people who have to work to be good at math. If I am naturally not good at math, I can change that by working very hard to get good at math; so I can change my ability to an extent, depending on how hard I work.

4.4. IS THERE A DIFFERENCE IN MINDSET SCORES ACROSS FIRST-YEAR INTRODUCTORY MATHEMATICS COURSES?

A Kruskal-Wallis test was conducted to answer the second research question, *Is there a significant difference in mindset scores across different degree programs?* Initially, distributions of the mindset scores looked similar for all groups, as assessed by visual inspection of a boxplot in Figure 1 below.

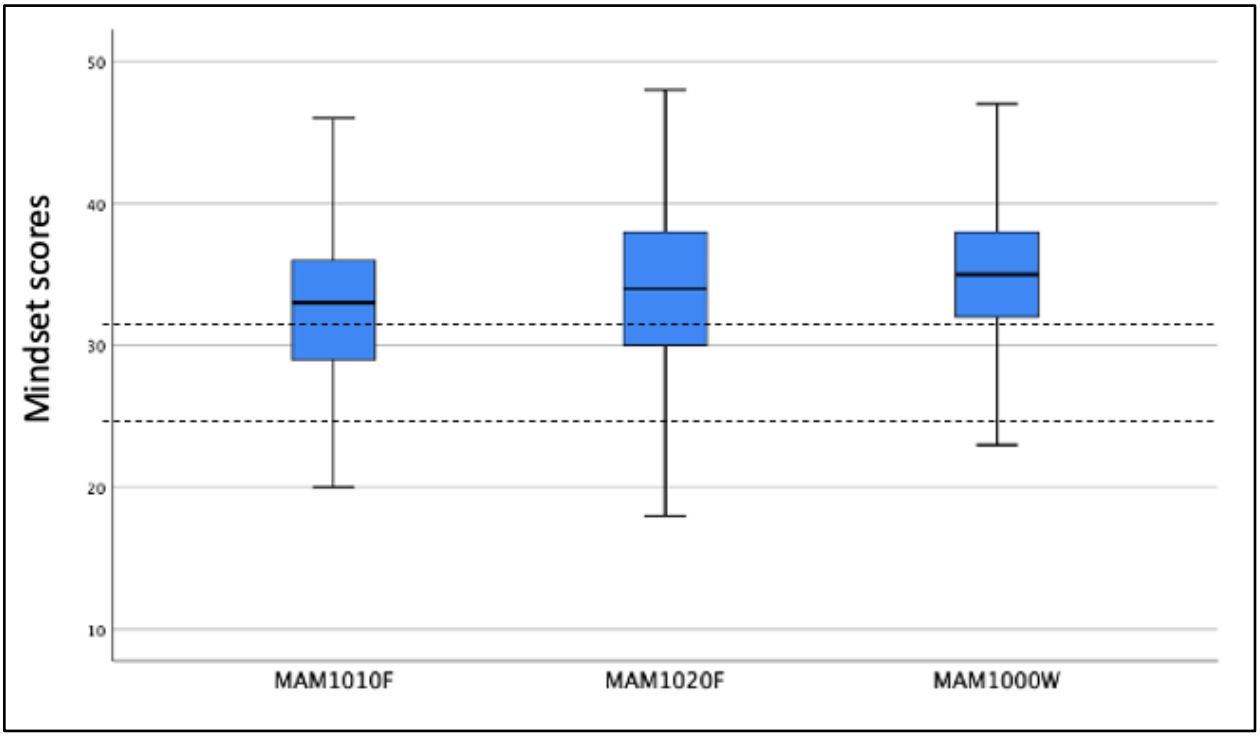

Figure 1: Boxplots of mindset scores for different groups of students.

Note: The whiskers extend to the lowest and the highest mindset scores, the line in the middle of the box represents the median. The dotted lines on scores 24 and 32 indicate mindset boundaries. Weighted scores below 24 are considered to be a fixed mindset while those above 32 are considered to be a growth mindset (Dweck, Chiu, & Hong, 1995). The numerical values for the mindset scores are as follows: MAM1010F (Min = 20, Median = 33, Max = 46), MAM1020F (Min =18, Median = 34, Max = 48) and MAM1000W (Min = 23, Median = 35, Max = 47). As can be seen in figure 1, most participants of this study had a growth mindset.

A Kruskal-Wallis test, which was run to determine if there were any differences in the mindset score distributions, revealed a statistically significant difference in mindset scores across the courses (MAM1000W: $n = 241$, MAM1010F: $n = 301$, and MAM1020F: n = 171). Median mindset

scores were statistically significantly different between the groups, $\chi^2(3, N = 713) = 30.429$, $p = 0.000001$.

However, the Kruskal-Wallis test does not tell the full story. It shows that there are differences in the mindset score distributions, but it doesn't tell where the difference lies. Subsequently, a series of pairwise comparisons were performed using the Mann-Whitney U tests to determine between which courses the difference in mindset scores distribution lies. To control for Type 1 errors (such as failing to observe a difference when in truth there is one), a Bonferroni adjustment was applied to the p-values. The significance level of 0.05 was divided by the total number of pairwise Mann-Whitney U tests (3). Therefore, a stricter significance level of 0.05/3 = 0.017 was used, which means that p-values higher than 0.017 indicate that the difference (between comparison groups) is not statistically significant.

Table 5: A summary of the results of the three Mann-Whitney U tests.

	Mann-Whitney U	**Z score**	**p-value**
MAM1000W & MAM1010F	21 166	-4.628	0.000004
MAM1000W & MAM1020F	25 520	-0.119	0.905
MAM1010F & MAM1020F	16 519	-4.048	0.000052

This post hoc analysis revealed statistically significant differences in median mindset scores between the MAM1000W and MAM1010F ($p < 0.017$) and between the MAM1010F and MAM1020F ($p < 0.017$) groups. However, there was no statistically significant difference between MAM1000W and MAM1020F mindset scores distributions ($p > 0.017$).

4.5. HOW DO MINDSET SCORES OF STUDENTS AT A SOUTH AFRICAN UNIVERSITY COMPARE WITH INTERNATIONAL SCORES?

In this subsection, the third research question (i.e., *Is there a difference between mindset scores of first-year students at the University of Cape Town and post-secondary students in other countries?)* is addressed. The third research question will help to understand the University of Cape Town students better, especially compared to other countries. As seen in the table below, the scales used in the studies have a different number of Likert options. Thus, it is difficult to make comparisons across studies without converting the scores to a common scale. The mindset scores were converted to percentages using a method used by Campbell et al. (2021). The parameters used for the conversion are detailed in the appendix. Table 6 below shows the mindset score percentages of the international studies discussed in section 2.4, where high percentages indicate a growth mindset. Only the studies from Table 1 that reported data about the mindset scores, which would allow for the calculations of mindset score percentages, were included in Table 6.

Table 6: Mindset score percentages of University of Cape Town first-year students compared with undergraduate students in other countries.

Reference	Sample size	Location	Size of scale	Mindset score percentage	Cronbach's alpha
Chen and Wong (2014)	312	A university in Hong Kong	Six items on a six-point Likert scale	47.4%	0.95
Chen and Wong (2015)	418	A university in Hong Kong	Five items on a six-point Likert scale	46.8%	0.90
Dai and Cromley (2014)	330	An urban, mid-Atlantic university in the USA.	Eight items on a six-point Likert scale	66.2%	0.73
Gunderson et al. (2017)	190	A large public university in the USA	Four items on a six-point Likert scale	65.2%	Not reported
Shively and Ryan (2013)	159	Mid-western University in the USA	Eight items on a seven-point Likert scale	67.8%	Not reported
Tempelaar et al. (2015)	4 594	A university in the Netherlands	Eight items on a six-point Likert scale	67.6%	Not reported
The current study (2020)	**713**	**The University of Cape Town**	**Eight items on a six-point Likert scale**	**64.0%**	**0.501**

From Table 6 above, the current study's mindset score percentage is higher than that of the two universities in Hong Kong, while lower than the rest of the universities reported. It is worth noting that Cronbach's alpha coefficient for the current study is very low compared with the other studies reported in the table. Moreover, this Cronbach's alpha coefficient is below the minimum level suggested by DeVellis (2012) of 0.7.

4.6. IS THERE A RELATIONSHIP BETWEEN MINDSET SCORES AND CHANGES IN MATHEMATICS SCORES?

To answer the fourth research question, Kendall's rank correlation was run to assess the relationship between mindset scores and changes in students' mathematics grades. Kendall's rank correlation coefficient values can range between -1 and 1 with -1 indicating a perfect negative relationship (i.e. low mindset scores correspond with an increase in mathematics grades, and high mindset scores correspond a decrease in mathematics grades) and +1 indicating a perfect positive relationship (i.e. low mindset scores correspond to a decrease in mathematics grades, and high mindset scores correspond to an increase in mathematics grades).

Grade changes between class test 1 and class test 2 were compared with mindset scores, followed by grade changes between class test 1 and the final exam. This was done for (a) all the students, (b) students who failed the first class test, and (c) students who scored 75% or more in the first class test.

Mindset scores vs mathematics grades changes for all the students

Table 7: Kendall's rank correlation coefficients for the correlation test for all students enrolled in introductory calculus courses.

	Test 1 to Test 2 changes			**Test 1 to exam changes**		
	Kendall's Tau_b	n	p-value	Kendall's Tau_b	n	p-value
MAM1000W	0.024	192	0.636	0.039	193	0.438
MAM1010F	0.077	297	0.054	0.044	290	0.275
MAM1020F	-0.066	149	0.242	0.026	148	0.651

The results presented in Table 7 indicate that there are mostly weak positive associations between mindset scores and mathematics grade changes across all the courses, which are not statistically significant (p-values greater than 0.05). Moreover, there is a weak negative association (not statistically significant) between mindset scores and mathematics grades in MAM1020F considering grade changes between the first and the second class test.

Mindset scores vs mathematics grades changes for students who failed the first class test

Table 8: Kendall's rank correlation coefficients for the correlation test for students who failed the first mathematics class test.

	Test 1 to Test 2 changes			**Test 1 to exam changes**		
	Kendall's Tau_b	n	p-value	Kendall's Tau_b	n	p-value
MAM1000W	-0.007	25	0.963	0.073	26	0.611
MAM1010F	0.281	31	0.031	0.195	21	0.225
MAM1020F	0.000	13	1.000	0.026	13	0.902

Table 8 shows that there is a weak correlation between mindset scores and mathematics grade changes for the student who failed the first test across all the courses. The correlation between mindset scores and mathematics score changes (between class test 1 and class test 2) for the MAM1010F group is statistically significant ($p = 0.031$) while the other correlations are not statistically significant ($p > 0.05$).

Mindset score vs grade changes for students who scored 75% or more in the first class test

Table 9: Kendall's rank correlation coefficients for the correlation test for students who scored more than 75% in the first mathematics class test.

	Test 1 to Test 2 changes			**Test 1 to exam changes**		
	Kendall's Tau_b	n	p-value	Kendall's Tau_b	n	p-value
MAM1000W	0.001	79	0.990	-0.011	80	0.887
MAM1010F	0.111	105	0.102	0.082	105	0.227
MAM1020F	-0.043	55	0.646	0.144	54	0.131

Table 9 shows that there are weak correlations between mindset scores and mathematics score changes across all the courses, the correlations are not statistically significant (p-values > 0.05).

4.7. SUMMARY

The preceding sections of this chapter presented the analysis of the qualitative and quantitative data. The response rates for this study are acceptable and representative of the population. The data presented aimed to answer the four research questions.

The reliability of MAP was assessed using the Cronbach's alpha coefficient, and the validity of the instrument was examined through follow-up interviews with participants who scored low on the mindset scale. The Cronbach's alpha coefficients were low (i.e., below 0.60) for the three courses included in the study (MAM1000W, MAM1010F, and MAM1020F) and unacceptable (i.e., below 0.00) for MAM1004F. This resulted in the exclusion of the MAM1004F course from further analysis. There was a poor correlation between some students' mindset scores and their interview responses suggesting that MAP may not be valid for University of Cape Town first-year mathematics students.

The mindset scores of the students enrolled in three degree programs (Commerce, Engineering, and Science) were compared. First, the Kruskal-Wallis test was conducted to detect statistically significant differences (if any) in the distributions of the mindset scores. Once the differences were established, a series of Mann-Whitney U tests were conducted to determine where the differences lay. The mindset scores of the students enrolled in commerce degrees were significantly (statistically) lower than those of students enrolled in engineering and science degrees.

Furthermore, the mindset scores of the University of Cape Town students were compared with the mindset scores of the students of other universities. The mindset scores were converted to percentages for ease of comparison. The University of Cape Town mindset scores were higher than two universities in Hong Kong and lower than several universities in the USA and the Netherlands.

Finally, the statistical relationship between mindset scores and changes in mathematics grades was determined using Kendall's rank correlation. These correlations were run for all students, for students who failed the first class test, and for those who scored above 75% on the first class test. There were weak correlations, that are not statistically significant, between mindset scores and change in grades (between the first class test, the second class test, and the final exam) in first-year mathematics courses.

This presentation of the qualitative data and the analysis of the quantitative data were aimed at answering the research questions. The next chapter discusses the implications of these findings and recommendations for future studies.

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

5.1. INTRODUCTION

The purpose of this study was to (a) measure the reliability of the Mindset Assessment Profile on University of Cape Town first-year students, (b) investigate if there is any significant difference in mindset scores profiles across different degree programs, (c) compare the mindset scores of a South African university (UCT) with other international universities, and (d) investigate the relationship between mindset scores and academic performance. This chapter includes a discussion of major findings as related to the literature on mindset and academic achievement. This chapter concludes with a discussion of the limitations of the study and areas for future research.

5.2. DISCUSSION AND LIMITATIONS

Reliability of the Mindset Assessment Profile

Cronbach's alpha coefficient was used to assess the reliability of the Mindset Assessment Profile. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. However, the coefficient has no lower limit (Gliem & Gliem, 2003). The closer Cronbach's alpha coefficient is to 1 the more reliable the scale is. Ideally, the Cronbach alpha coefficient of a scale should be above .70 (DeVellis, 2012). George and Mallery (2003) provided the following rules of thumb: "_ > 0.9 – Excellent, _ > 0.8 – Good, _ > 0.7 – Acceptable, _ > 0.6 – Questionable, _ > 0.5 – Poor, and _ < 0.5 – Unacceptable" (p. 231). Taber (2018) argued that Cronbach's alpha values of between 0.6 and 0.7 are acceptable for science education research.

Cronbach's alpha coefficients for the Mindset Assessment Profile in this study were found to be moderately low ranging from 0.484 to 0.642. Cronbach's alpha values are quite sensitive to the number of items in the scale; the low values could be attributed to the low number of items in the mindset scale (i.e., eight items). However, several studies that used the same scale (or similar scales with the same number of items) have reported higher Cronbach's alpha values. Several possible reasons for the low values in this study are discussed next.

The use of the term "intelligence" may have been problematic. Jones et al. (2009) asserted that "students have a range of beliefs about the definition of intelligence" (p. 3). In the Mindset Assessment Profile, the participants were asked to rate the level to which they agree or disagree with statements relating to intelligence. However, "intelligence" was not defined, and students' different interpretations of the term might have affected the internal consistency of the scale.

Moreover, the low Cronbach's alpha of the scale in the current study might be attributed to the social desirability bias of the participants. Social desirability bias is "the tendency to underreport socially undesirable attitudes and behaviours and to over-report more desirable attributes" (Latkin et al., 2017, p.2). Participants may have wanted to give the "right" answers to impress the lecturers, potentially reducing the validity of the responses. This might also explain why a high number of participants scored high on the mindset scale.

Studies that used the Mindset Assessment Profile (MAP) to assess mindset typically reported low Cronbach's alpha values. Kelley (2018) reported Cronbach's alpha values of 0.42 and 0.48 when using MAP to assess mindsets of 25 students at different times. Kelley further suggested that reliability may be increased by using the three larger scales from which the MAP draws on, described in Blackwell, Trzesniewski and Dweck (2007). The current study confirms that the MAP needs to be improved and future studies should consider using the larger scales or other mindset scales.

In their recent study, Burgoyne and Macnamara (2020) rigorously assessed the reliability and validity of the MAP in a sample of 992 undergraduates. They concluded that the MAP is multidimensional and not solely an indicator of mindset but also students' beliefs about cognition and goal orientation. They further argued that the MAP is correlated more strongly with cognition than with mindset. After doing item-level analyses, they reported that six of the eight items in the MAP correlated more strongly to cognition and goal orientation than mindset. Furthermore, two of the eight items did not correlate significantly with mindset. In light of these results, Burgoyne and Macnamara strongly recommended against using MAP as a measure of mindset. The Cronbach's alpha coefficients for the current study support Burgoyne and Macnamara's recommendation. This implies that the MAP is not a good measure of mindset, and the low Cronbach's alpha coefficients in the current study corroborates Burgoyne and Macnamara's findings.

There are other versions of the mindset scale as discussed in the literature review section. Further research on the reliability of different scales would be a great step into obtaining a reliable scale for undergraduate students at the University of Cape Town.

Mindset profile of University of Cape Town students

On average, the participants of the study lean towards the growth mindset region of the mindset spectrum (i.e., they scored above 32 points on the mindset scale, Dweck, Chiu, & Hong, 1995). This could be because the students are young adults and may have overcome several academic challenges in high school, which could have made them acknowledge that abilities can be developed through effort. This view is supported by the interview responses of Student A who talked about how his high school struggles made him believe that he can improve his performance. When completing the questionnaire for the current study, the students based their responses on their high school experience since the survey took place at the beginning of their first year. Furthermore, the students self-selected to participate in the study. This shows motivation and willingness to participate in academic projects, which may indicate a growth mindset.

Statistical tests that were run to check for significant differences in mindset scores across the courses (to answer the second research question) revealed that students enrolled in commerce degree programs scored significantly (statistically) lower than students enrolled in engineering and science degree programs on the mindset scale. It is worth noting that commerce degree programs are non-STEM majors (STEM stands for science, technology, engineering, and mathematics). STEM degree programs at the University of Cape Town require higher mathematics grades from high school than non-STEM degree programs. Given that STEM degree programs require students to have a stronger mathematics background, students who enrol in STEM majors may think that

their degrees are more challenging. This willingness to face challenges is indicative of a growth mindset. This is a possible reason why students enrolled in science and engineering degree programs score higher on the mindset scale.

Mindset scores of South African university students compared to other post-secondary students in the world

One of the objectives of this study was to determine how mindset scores of the University of Cape Town students compare with the mindset scores of post-secondary students in other countries. Similar to how differences in mindset between students in different degree programs may help in designing appropriate strategies to develop growth mindset, comparing mindset scores across countries may direct future work on developing growth mindset by exploring what contributes to differences in mindsets in different countries.

As reported in Chapter 4, South African university students scored lower than university students in the USA while scoring higher than Hong Kong university students. Interestingly, the current study corroborates the findings of Sun et al. (2021) that Chinese students are more likely to hold fixed mindset beliefs about intelligence than US students. Future studies can investigate why and how the mindset scores differ across countries. Although the mindset scores were converted into percentages for ease of comparison, it would be interesting to compare mindset scores on the same mindset scale

Mindset and academic performance

The final research question of the study was: *Is there a statistically significant correlation between mindset scores and academic performance in first-year mathematics courses at the University of Cape Town?* As discussed in the literature review, several correlational studies have reported significant links between mindset and academic performance. In this study, there was no statistically significant correlation between mindset scores and change in performance in mathematics. Several reasons for the weak and insignificant correlation between mindset scores and academic performance are discussed next.

There are other factors such as academic background (Van den Broeck et al., 2019) and workload (Kizito, Munyakazi, & Basuayi, 2016) that can affect performance in mathematics that were not considered in this study. Moreover, this was an observational study; no mindset interventions were done to influence students' mindsets. Most researchers that reported a significant correlation between academic performance and mindset scores controlled for other factors and had mindset interventions to teach students about the malleability of intelligence and plasticity of the brain.

Furthermore, the mindsets of the participants in this study were assumed to remain constant for the duration of the academic year. Although there are studies that have shown no evidence of mindset change in university over an academic year (Robins & Pals, 2002; Gunderson et al., 2017), several researchers have reported that mindset can change in university in the absence of mindset interventions (e.g. Dai & Cromley, 2014; Kinlaw & Kurtz-Costes, 2003). The mindset scores in this study were measured once before the participants wrote their first mathematics class tests; this is one of this study's limitations. Academic performance can influence mindset (Gonida et al.,

2006). The fact that students' mindsets may have been changing as a result of their university experience can affect the correlation between mindset and academic performance. Future studies should assess mindsets at different stages of the study.

Moreover, as assessed by Cronbach's alpha coefficient in the current study, the MAP is not a reliable instrument for measuring mindset for the University of Cape Town population. Inaccurate mindset scores data could have affected the correlation between mindset and academic performance.

5.3. CONCLUSIONS AND FUTURE DIRECTIONS

This research aimed to (a) assess the reliability of the Mindset Assessment Profile (MAP) for the University of Cape Town population, (b) compare mindset scores of students enrolled in a subset of commerce, science, and engineering degree programs, (c) compare mindset scores of South African university students with mindset scores of post-secondary students in other countries, and (d) investigate the relationship between mindset and academic performance. The implications of the results of the current study and recommendations for future research are outlined in the paragraphs that follow.

Based on the analysis of the quantitative and qualitative data obtained in this study, it can be concluded that the MAP is not a reliable measure of mindset for the University of Cape Town students. Further research should explore different mindset scales to determine the best scale for the University of Cape Town population.

The second objective of this study was to compare mindset scores of students enrolled in commerce, engineering, and science degrees. Although the lack of probability sampling in this study limits the generalizability of the results, the results clearly illustrate that commerce students score lower than science and engineering students. Based on this conclusion, growth mindset interventions are more likely to show a shift towards growth mindsets when they target students in commerce degree programs rather than students in science and engineering degree programs. Further research could investigate why commerce students score lower than science and engineering students on the mindset scale.

Thirdly, mindset scores of South African university students were compared with mindset scores of students from international universities. The results indicate that South African students' mindset scores were lower than those of the USA and the Netherlands students and higher than Hong Kong students. Future work should explore what contributes to differences in mindsets in different countries and cultures.

The final objective of this study was to investigate the relationship between mindset and academic performance. Based on the results of this study, there is no significant correlation between mindset and change in academic performance in first-year mathematics courses at the University of Cape Town. Again, it should be noted that the Mindset Assessment Profile was not a reliable measure of mindset, so this result cannot be generalised. Further research should investigate the correlation between mindset and academic performance using a reliable scale.

Finally, the new contributions of this study are summarised as follows.

- The MAP is not a reliable measure of mindset for the University of Cape Town students.
- Students enrolled in commerce degree programs at the University of Cape Town have lower growth mindset scores than students enrolled in science and engineering degree programs.
- This study serves as a springboard for further research on mindsets at the University of Cape Town and perhaps other South African universities.

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APPENDIX

Call for students to complete the online questionnaire

The following announcement was sent out to all the students at the beginning of the semester :

“We are doing some research about mathematics education, in order to see how we can improve things. We have set up a questionnaire which is on Webassign, and is called "Learning Questionnaire". It is a very short questionnaire, with tick boxes for answers and should take less than 10 minutes. In it, there are two boxes where you can give permission to let the answers from the questionnaire, and your class tests grades, be used for the research that we are doing. We will be able to analyse data from anyone who ticks yes to these. Your names will not be included in any study, so you don't have to worry about other people seeing your grades who would not be able to otherwise. Taking part in this will really help us, thank you in advance.”

Interested students completed the questionnaire as requested.

Mindset questionnaire

At beginning of the questionnaire, the following message was displayed:

“Thank you for choosing to participate in this educational research. There are no right or wrong answers so feel free to answer honestly. Your student number will be used to link your course results to your responses, however, your student number or name will not be used in any research publications (e.g. journal articles, conference presentations or posters). This questionnaire will take you approximately 8 minutes. Please feel free to ask if any of the questions are unclear. The deadline for this questionnaire will be Wednesday 14th March at midnight.”

This was followed by the statement below, to which the students had an option to either agree or disagree.

“I agree that my data can be used in educational research. No personal details will be published.”

The questionnaire used to assess student mindset in this study is called the Mindset Assessment Profile (Mindset Works, Inc., 2012). The questionnaire consists of the eight statements in the table below. The respondents were asked to read the eight statements and rate the level to which they agree or disagree as follows. 1 = Disagree a lot, 2 = Disagree, 3 = Disagree a little, 4 = Agree a little, 5 = Agree , 6 = Agree a lot.

1. No matter how much intelligence you have, you can always change it a good deal.
2. You can learn new things, but you can't really change your basic level of intelligence (*).
3. I like my work best when it makes me think hard.
4. I like my work best when I can do it really well without too much trouble (*).
5. I like work that I'll learn from even if I make a lot of mistakes.
6. I like my work best when I can do it perfectly without any mistakes (*).
7. When something is hard, it just makes me want to work more on it, not less.
8. To tell the truth, when I work hard, it makes me feel as though I'm not very smart (*).

Note: items marked with (*) were reverse scored.

The scores for each statement were added together, high scores indicated agreement with the growth mindset belief.

Follow-up interview questions

At the beginning of each interview, participants were asked to grant permission for the interviewer to make audio recordings of the interview for transcription purposes. The following questions were asked in the one-on-one interviews:

1. Describe the behaviour of a successful academic achiever at university.
2. Describe the behaviour of a student not likely to be successful at university.
3. What do you think are the reasons why some students fail although they got accepted into university based on high school marks?
4. Has your approach to your university studies changed over the semester/year or compared to high school? If so, in what way?
5. Do you think students who get excluded could become graduates? If so, what would have to change for that to happen?
6. Do you think a person's academic ability is something they can control or is it more like eye colour that is a fixed quality?

Converting mindset scores to percentages

The mindset scores were converted to percentages using the following formula described in Campbell et al. (2021).

Mindset score % = (mindset score – lowest value on scale)/(highest value on scale – lowest value on scale).

For example, on a scale of 1 to 6, a score of 3.5 would be 50%, a score of 3 would be 40% and a score of 6 would be 100%.