Masters Research Report

Metacognition and Daily Failures in Working Memory: A Deeper Understanding of University Students' Academic Achievement.

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Abstract

Working memory is said to be one's ability to keep newly absorbed information in mind for a period, all whilst using this knowledge for the activity that one is performing (Tariq & Noor, 2012). Whereas metacognition is the capacity to analyse, comprehend, and direct one's own learning (Schraw & Dennison, 1994). Literature suggests that deficits in working memory and metacognitive capacity may have an impact on academic performance, however, little is known whether this is the case of university students in SA. This study investigated correlations between metacognition and daily failures of working memory, and academic achievement in a sample of full-time university students in one university in Johannesburg (n=190). Participants were asked to complete the Metacognitive Awareness Inventory and the Working Memory Questionnaire. Additionally, the best three marks reported in percentages by the participants is used as the measure for academic achievement. Results indicated that there is a statistically significant correlation between working memory and metacognition ($r = -.288$, $n = 190$, $p = <.001$). However, working memory and metacognition, as assessed in this study, does not seem be linked to academic achievement.

Key words: working memory, metacognition, academic achievement, university students.

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Thank you to the participants, without your selfless agreement this study would not have been possible.

Plagiarism Declaration

I Katya Nadia Menschy, 2388147, declare that this research report is my own, unaided work. It is submitted for the degree of Master of Arts in Psychology by Coursework and Research Report at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at this or any other university.

Signed Katya N. Menschy

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Dedicated to my wonderful Granddad, Roy.

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1. Chapter One: Introduction and Literature Review

1.1 Introduction

Universities in South Africa have a high incidence of drop out, due to poor academic achievement during the first year of studies (Bantjes et al., 2021). Risk factors include mental health problems and ADHD related symptomatology (Arnold et al., 2020), as well as financial difficulties (van Zyl, 2015). Academic achievement and dropout rates are a significant problem for universities in Africa and South Africa (Bantjes et al., 2021). The reasons for dropout rates rising have often been attributed to financial challenges (van Zyl, 2015), mental health issues (Makhubela, 2021; Van et al., 2020; Sheridan et al., 2016; Chu et al., 2020), and ADHD (Arnold et al., 2020). Other cognitive-related variables, such as poor metacognitive awareness, aimless or unenthusiastic behaviour, and procrastination (Akinsola et al., 2007; Coutinho, 2007) have been found to correlate with poor academic performance.

Metacognition and working memory are said to be related (Coutinho, 2007; Du Toit, 2017; Komori, 2016). Working memory is said to be one's ability to keep newly absorbed information in mind for a period, all whilst using this knowledge for the activity that one is performing (Tariq & Noor, 2012). Whereas metacognition is the capacity to analyse, comprehend, and direct one's own learning (Schraw & Dennison, 1994). Metacognition has been recognised to be a strong predictor of academic achievement and learning (Coutinho, 2007; Costa & Kallick, 2001; Pradhan & Das, 2021; Van der Stel & Veenman, 2010). It is believed that having the necessary metacognitive skills and knowledge can help students excel in their studies (Young & Fry, 2008). Thus, by focusing on one's accuracy, individuals are in turn enhancing their own metacognitive abilities, by focusing attention on recognizing task-relevant targets, which may improve cognitive performance. Therefore, it can be hypothesised that, for these reasons, working memory and metacognition may also contribute to the variations in academic performance in university students. Hence, by university students focusing their attention on recognizing task-relevant tasks, rather than task-irrelevant tasks, they are in turn using their working memory to improve the metacognitive abilities (Adam & Vogel, 2017). Understanding this can help direct the attention to these variables in order to improve academic achievement and reduce the risk of exclusion for university students in SA, who are facing many challenges that already put them at risk (Du Toit, 2017, Scott, 2018).

To date, research in these area has observed several outcomes; (a) students who have metacognitive skills are more likely to make improvements in their search techniques by continuously monitoring their progress; (b) learners who are metacognitively aware are more

knowledgeable and productive; (c) the ability to control and monitor the behaviour that influences an individual's WM on tasks can be used to guide strategy implementation and strategy recognition, is said to be regulated by metacognition; (d) focusing one's attention is critical to the differences in working memory among individuals, this suggests that the capacity to expand one's attentional capacity can increase with practice; (e) students with daily failures in working memory may take considerably longer to memorise new information that is presented to them at school or at university.

The majority of research in the area of working memory has examined working memory as the construct and its relationship with metacognition, as well as its relationship to academic achievement (Bembenutty, 2009; Coutinho, 2007; Howlett et al., 2021; Schraw and Dennison, 1994; Sreena & Ilankumaran, 2018; Sperling et al., 2004; Schwartz, 2006; Young & Fry, 2008). The focus has been on western, educated, industrialised, rich, and democratic (WEIRD) populations, whose individuals are 6 years old and up until university (Kincannon, Gleber, & Kim, 1999; Nietfeld, Cao, & Osborne, 2005; Romainville, 1994; Schleifer & Dull, 2009; Schraw, 1994; Thiede, Anderson, & Therriault, 2003; Uwazurike, 2010; Young & Fry, 2008). Thus, leaving a gap in the literature for examining the effect of daily failures of working memory, and how these may relate to the student's metacognition and academic achievement in a non-WEIRD population.

This quantitative cross-sectional, correlational study will specifically focus on exploring the relationships between metacognition, daily failures of working memory, and academic achievement. For this reason, the researcher's intent was to gain a deeper understanding of how daily failures in working memory and metacognition in university students can explain academic achievement.

To investigate these aims, several correlational analyses were implemented, as a way to determine whether there was a correlation between specific sets of variables, such as failures in working memory, metacognition and academic achievement, and if any, what was the direction and strength of the relationship.

Academic achievement was operationalized, for this study, as the percentage the participants obtained as their academic average for the previous year. Metacognition in this study was assessed in terms of the participants capacity for the regulation of cognition and their knowledge of cognition, which was measured using the Metacognitive Awareness Inventory (MAI) (Schraw and Dennison, 1994). However, daily failures of working memory will not be

expressed as the well-known construct of working memory, but rather as a separate construct which seeks to describe the daily failures of working memory reported by university students by using the WMQ (Vallat-Azouvi et al., 2012).

The following chapters include, chapter 2, titled Literature and Theoretical Review, where conceptual and theoretical background evidence is provided on metacognition, daily failures of working memory, and academic achievement, and critically examined. Furthermore, it includes the rationale, research questions, and hypotheses. Chapter 3 consists of the Methods section, this chapter includes the research design, sample, procedures, instruments, methods of analysis, and ethical considerations.

Chapter 4 consists of the Results section, this chapter presents the results of analyses that were run on the data collected. Instrument reliability, hypotheses, research questions. Moreover, Chapter 5 contains the Discussion section (begin with discussion of each hypothesis/research questions following the order of the results chapter). The discussion compared the results to those found in previous studies, including theoretical and practical implications, limitations of the study, and directions for future research. Chapter 6 presents concluding statements, as well a considerations of the limitations and directions for future research.

1.2 Literature and Theoretical Review

The literature review chapter provides a summary on the research assessing the relationship between metacognition, daily failures of working memory, and academic achievement with specific reference to university students. Additionally, it presents the basic concepts and definitions/debates around these constructs.

1.2.1. Conceptualising Metacognition

Background and Context

Metacognition is the capacity to analyse, comprehend, and direct one's own learning (Schraw & Dennison, 1994). The difference between cognition and metacognition is that the latter requires the ability to comprehend how tasks are completed, while the former requires the ability to perform cognitive skills (Çetin, 2017). The concept of metacognition can also be used to describe an individual's ability to know what they can and cannot do (Akpur, 2017). Thus, knowledge of cognition and regulation of cognition have been recognised as the two main components of metacognition in earlier analyses and can be found in the MAI (Brown, 1978; Flavell, 1979; Paris & Winograd 1990).

Specifically, regulation of cognition demonstrates that there are five vital skills that are involved in this process (Schraw & Dennison, 1994; Schraw & Moshman, 1995). These skills include evaluation, comprehension monitoring, and planning (Schraw & Dennison, 1994; Schraw & Moshman, 1995), as well as information management strategies, and debugging strategies (Schraw & Dennison, 1994). It is important to consider these five skills (subcategories) separately, as well as in totality to one's regulation of cognition. Regulation of cognition refers to metacognitive activities which assist individuals in controlling their learning or thinking (Schraw & Moshman, 1995).

Having established what skills are involved in the regulation of cognition component, it is vital to discuss them further. Thus, the planning process involves identifying a new situation and coming up with a strategy to bring about solutions, to achieve the goals that have been set out by the individual, and utilizing the available resources (Reisoğlu et al., 2020; Schraw & Moshman, 1995). The monitoring process involves the individual's awareness of their performance in relation to the planned process (Reisoğlu et al., 2020; Schraw & Moshman, 1995). Whereas the evaluation process involves the evaluation of the results of their own learning and the organisation procedures (Reisoğlu et al., 2020; Schraw & Moshman, 1995). In addition to the three processes outlined above, the information gathering process needs to be established. According to various studies (Blummer & Kenton, 2014; Ge et al., 2016; Huertas et al., 2017; Şendurur & Yıldırım, 2018; Zhang et al., 2015), the development of metacognitive skills is vital for individuals who are involved in the information search process. These skills help them complete complex tasks, evaluate information, and solve problems related to the information gathering process (Zhang et al., 2015).

Another line of thought on knowledge of cognition is concerned with what individuals have come to know regarding their own cognition or what they understand about cognition in general (Baker, 1989; Schraw & Moshman, 1995). The knowledge of cognition is regarded as the basis for individuals' expectations regarding the various factors and actions (i.e., studying) that can affect the cognitive effort (Çetin, 2017). There are three different types of metacognitive awareness (knowledge of cognition), namely, conditional knowledge (understanding the how, when, and why of cognition and strategies), declarative knowledge (understanding things about oneself and strategies), and procedural knowledge (knowledge of how to use these approaches) (Schraw & Moshman, 1995). Which in turn, encourages the introspective component of student's metacognition (Schraw & Dennison, 1994).

Metacognitive Awareness and the Metacognitive Awareness Inventory Instrument

Metacognition is regarded as an object of cognition, while introspection is an object of conscious experience (Mega & Volz, 2014). Reflecting on one's experience is said to be introspection, and it allows one to describe one's thoughts about what one is experiencing (Mega & Volz, 2014). This allows one to become more meta-aware, as it allows an individual to have a deeper understanding of what they are experiencing (Mega & Volz, 2014). Metacognition can be assessed in many ways, specifically the MAI (Metacognitive Awareness Inventory) aligns to the conceptualization of metacognition described above. It should also be used to measure the student's academic achievement, which can involve various cognitive skills. Thus, the goal of metacognitive assessments is to provide a comprehensive assessment of the various components of metacognition (Schraw & Dennison, 1994). These include regulation of cognition and knowledge of cognition (Schraw & Dennison, 1994). However, the use of MAI and its use to measure cognitive abilities and academic performance will be discussed in detail later.

Therefore, students with metacognitive awareness (i.e., those who utilise regulation of cognition and knowledge of cognition) can organise, sequence, and keep track of their learning in a way that directly enhances performance (Mytkowicz et al., 2014; Schraw & Dennison, 1994). The concept of metacognition refers to the use of various self-regulatory mechanisms to solve a problem that an individual experiences during the learning process. This process carried out through the individual monitoring the cognitive activities throughout the course of the learning process, and thus, the results are then evaluated (Livingstone, 2003).

Previous Studies

Evidence suggests that students who have metacognitive skills are more likely to improve their search techniques by continuously monitoring their progress (Catalano, 2017; Frerejean et al., 2018; Ge et al., 2016). This can help them develop effective strategies and become more aware of where to go next when looking for information that is applicable to their studies (Raes, Schellens, De Wever, & Benoit, 2016). The results of the study by Howlett et al. (2021) revealed that academic coaching significantly improved the metacognition of university students. Through interactions with their peers and teachers (Howlett et al., 2021). This process can be facilitated by the learning environment's dynamic setting, which allows them to reflect on and model their skills and provides them with the opportunity to control and manage their learning (Howlett et al., 2021). Notably, the relationship between metacognition and academic achievement will be discussed in further detail in the paragraphs below.

1.2.1 The Relationship between Academic Achievement and Metacognition

Background and Context

Metacognition is recognised as a strong predictor of academic achievement and learning (Coutinho, 2007; Costa & Kallick, 2001; Pradhan & Das, 2021; Van der Stel & Veenman, 2010). The goal of education is to develop lifelong learners who are capable of handling new situations and learning from their mistakes (Du Toit, 2017). It is believed that having the necessary metacognitive skills and knowledge can help students excel in their studies (Young & Fry, 2008). Students with metacognitive skills are more aware of their own learning process and can easily adopt the learning styles that are appropriate for them (Pradhan & Das, 2021). Due to the varying learning styles of students, their abilities and metacognitive skills vary (Pradhan & Das, 2021). Therefore, it is important that students can assess their metacognition, as this can help them determine if their academic success is related to their skills and knowledge (Young & Fry, 2008).

Previous Studies

The study conducted by Coutinho (2007) examines the relationship between academic success, mastery goals, and metacognition, as well as the mediation effect of performance goals on the relationship between academic performance and mastery goals. The results of the analysis support the notion that students with mastery objectives (in terms of their academic careers and curriculum, students should also have the necessary skills and knowledge to make informed decisions) can reap the rewards of their academic success (Coutinho, 2007).Thus, learners who are metacognitively aware are more knowledgeable and productive (Coutinho, 2007; Du Toit, 2017; Schraw & Dennison, 1994).

Moreover, a meta-analysis conducted by Raoofi et al. (2014) reveals that metacognitive knowledge can help improve an individual's language performance, comprehension ability, or academic writing. Thus, the successful student is known to develop a passion for learning and are committed to improving their performance in various aspects of their studies (Hassanbeigi et al., 2011). These habits are also reflected in their ability to plan and organise their studies and help them make informed decisions and develop goals (Hassanbeigi et al., 2011).

Furthermore, the rise of metacognition studies can be observed in the field of higher education. These studies examine the link between academic achievement and various metacognitive traits, such as regulation of cognition or knowledge of cognition (Pradhan & Das, 2021). A positive relationship is found between metacognitive awareness and academic

achievement in university students (Abdellah, 2015; Al-oqleh et al., 2019; Akpur, 2017; Gaylo & Dales, 2017; Mohammadi et al., 2015; Pudiquet, 2019; Rum et al., 2016; Sawhney et al., 2015). Further studies reveal that the link between academic achievement and metacognitive awareness is influenced by the academic field of study and environment (Nongtodu et al., 2017; Pradhan & Das, 2021).

Metacognitive Awareness and the Student

Having established that metacognition helps students learning, and in turn helps academic achievement, this section will now focus on the how metacognition can be improved via training which in turn has a direct influence on students' academic achievement. It is maintained that students can improve their academic performance by implementing metacognitive strategies, to help them develop their cognitive abilities and mastery of various learning domains, such as mathematics, problem solving, reading, academic writing, communication, language, reasoning, and memory, as well as in personal, social, and emotional domains (Bembenutty, 2009; Coutinho, 2007; Du Toit, 2017; Pradhan & Das, 2021; Sreena & Ilankumaran, 2018).

The notion stands that metacognition should be taught to students as this skill can be improved, thereby students mastering their metacognitive and cognitive capabilities helps them to absorb information efficiently, apply their knowledge and skills to new contexts, and establish themselves as lifelong learners (Du Toit, 2017). Given the many different contexts in which metacognition can improve academic achievement, educational institutions across the world are looking for ways to expand academic learning by utilising the cognitive abilities of their students to regulate and monitor their progress. (Bembenutty, 2009; Pradhan & Das, 2021) In order to do so, they require that learners are competent and efficient (Pradhan & Das, 2021). As previously discussed, metacognition is a skill which helps students develop their cognitive tools, which in turn, makes them more successful in their studies and perform better in various academic subjects (Akben, 2020; Coutinho, 2007; Du Toit, 2017; Schraw & Dennison, 1994). Studies have shown that students with metacognition are more likely to achieve their desired results in university (Kincannon, Gleber, & Kim, 1999; Nietfeld, Cao, & Osborne, 2005; Romainville, 1994; Schleifer & Dull, 2009; Schraw, 1994; Thiede, Anderson, & Therriault, 2003; Uwazurike, 2010; Young & Fry, 2008).

Building on from the idea that metacognition can be improved with training, the section below discusses the importance of assessing metacognition in order to provide insight into

metacognitive skills and identify shortcomings. Metacognition can help students develop their adaptive competence and improve their learning processes, therefore, it can also help students demonstrate their expectations and improve their learning outcomes (Coutinho, 2007; Du Toit, 2017). This can be done using various learning strategies. (Pradhan & Das, 2021) The students must be responsible for their own decisions when it comes to choosing and applying the learning methods. (Pradhan & Das, 2021).

The comprehensive taxonomy created by Oxford (1990) defined the various learning strategies that can be utilized to enhance the students' learning process. It highlights the multiple metacognitive competencies that can be used to develop their learning styles (Ulieru et al., 2008). Thus, with the help of metacognition, students can easily identify their own learning styles and abilities depending on the context, task, and situation (Pradhan & Das, 2021).

Furthermore, James and Ocpala's (2010) study found that teaching methods that incorporated metacognitive strategies and knowledge resulted in more interaction with the learning materials. Kincannon et al.'s (1999) study confirms that metacognitive instruction throughout the course material and content can improve both student learning, and student awareness. Furthermore, the way in which these students apply these learning strategies contributes to the way in which they grasp the modules content. Swerdzewski and Burchard's (2009) study found significant results when analysing the effects of implementing metacognitive learning and regulation into a course that focused on learning theories and applying practical strategies to other modules; this course significantly improved the students' skills. Moreover, Applegate et al.'s (1994) study states that students' metacognitive awareness improved when they were taught to monitor their reading processes and resulted in an improvement in their overall metacognitive awareness.

Compared to students with poorly functioning metacognition, those with good metacognitive skills performed well academically (Sawhney & Bansal, 2015). Furthermore, those with poor metacognition can benefit from metacognitive training to improve their skills, as individuals with poor cognitive capabilities are referred to as someone who gives a half-hearted attempt when completing assignments, or they are lazy when compared to their peers with higher metacognitive skills at university (Sawhney & Bansal, 2015). Through metacognition, students can become more strategic in their learning. For instance, they can

learn new information instead of focusing on what they already know or have learnt (Sawhney & Bansal, 2015).

Moreover, according to Wenden (1998) metacognitive knowledge is very important in language acquisition as it allows students to improve their own knowledge and self-directed their way to learn the language they want to. This concept is also referred to as "learner beliefs" (Wenden, 1999, p. 436). Through this process, students conclude on how to improve their learning and acquire the language. There is a lot of support for these assumptions, and several studies have shown that there is a positive relationship between knowledge and metacognitive beliefs (Meier et al., 2014; Wang et al., 2009; Zenotz, 2012).

Metacognitive Awareness and the Metacognitive Awareness Inventory

Several studies have been conducted on the regulation and knowledge of cognition using the MAI. Researchers have found that knowledge of cognition is related to the prediction of test performance and the accuracy of responses, and that the regulation of cognition is related to the intrinsic values of tasks and goals (Hammann & Stevens, 1998). In addition, the MAI has been used as a tool for assessing the academic achievement of students (Amzil & Stine-Morrow, 2013). The Metacognitive Awareness Inventory (MAI) assisted researchers in being able to identify the support that can be provided to help students improve their problem-solving and self-monitoring skills (Lee, Teo, & Bergin, 2009). Through the MAI, researchers have been able to study students' understanding and strategy use (Hartley, 2001; Mair, 2012). They have also attained scores for separate areas of metacognition (see Coutinho, 2007).

Furthermore, according to Young and Fry's (2008) study significant correlations were found between the MAI and academic achievement (M=206.85, SD=20.99). Furthermore, knowledge of cognition was positively correlated with students GPA and their end of year marks ($r= 0.26$, $p=<0.05$). Additionally, regulation of cognition factor was also positively correlated with students GPA, as well as their end of year marks ($r= 0.27$, $p=<0.05$). Therefore, these results found by Young and Fry (2008) provide support for the validity of the MAI and its relationship to academic achievement. Sperling et al. (2004) used the MAI to determine the metacognitive awareness of students. A significant relationship between the regulation of the cognition factor and knowledge of cognition was found. Additionally, the researchers also wanted to know if the MAI was related to other measures of educational achievement, such as the SAT scores and average high school grades. However, they discovered that the scores had

a negative correlation. Unfortunately, many university students are not able to effectively use their metacognitive tools to monitor their learning and solve problems (Du Toit, 2017).

Therefore, it can be stated that metacognition plays an important role in a student's academic achievement and performance at university, and in turn influences their cognitive ability to recognise their daily failures of working memory.

1.2.2 Conceptualising Working Memory, and its Relationship to Metacognition

Background and Context of Working Memory

Working memory is said to be one's ability to keep newly received information in mind for a period, all whilst using this knowledge for the activity that one is performing (Tariq & Noor, 2012). "Working memory can be thought of as the equivalent of being mentally online" (Tariq & Noor, 2012, p. 72). An individual's working memory is in charge of temporarily storing information for processing and active manipulation (Miyake & Shah, 1999). It is a multifaceted system that is involved in the regulation of certain cognitive functions, such as selective attentional control and executive functions. Hence, working memory is a vital component of our cognitive processes. It aids the processes of complex reasoning and language comprehension (Tariq & Noor, 2012).

In this study, however, the daily failures of working memory will be examined, rather than the construct of working memory. Hence, Individuals with daily failures in working memory may report having trouble memorising details like phone numbers, handling many activities at once, engaging in group conversations, and reading complicated texts (Fougnie et al., 2015; Vallat-Azouvi et al., 2012).

Working Memory and Baddeley and Hitch's model (1994).

Given that this study focuses on the WM failures by using the WMQ, it is important to describe the theoretical model behind this instrument, namely Baddeley and Hitch's (1994) model, which has been considered to be most suitable in this context to support the WMQ (Vallat-Azouvi et al., 2012). This three-component model of working memory is the most appropriate for the following reasons. Firstly, it contains a phonological loop, which is used for storing and manipulating speech-based information. Secondly, it contains a visuospatial sketchpad, which is used for storing and manipulating visual and spatial data. Thirdly, both are overseen by a central executive that serves as an attentional control network (Baddeley & Hitch, 1994). This framework can thus be related to three different sections of the WMQ, which

focus on short-term storage, executive aspects, as well as attention (Vallat-Azouvi et al., 2012); as there is a significant overlap between the notions of attention, executive function, and working memory (Vallat-Azouvi et al., 2012).

The phonological loop stores verbal information in a rapidly degrading phonological form, with strong correlations between verbal short-term memory abilities and both current vocabulary knowledge and new word learning, the phonological loop appears to play a crucial role in assisting vocabulary development (Engel et al., 2018). This element of working memory is perhaps the most straightforward and thoroughly researched (Baddeley & Hitch, 1994).

The phonological loop is believed to entail an articulatory control mechanism that is capable of refreshing the memory trace through subvocal rehearsal, within which phonological or acoustic stores exist where memory traces fade after around two seconds unless they are revived (Baddeley & Hitch, 1994). The same procedure can label a visual input through sub-vocalization and then store it in the phonological store (Baddeley & Hitch, 1994).

The visuospatial sketchpad stores a finite quantity of visual and spatial data (Engel et al., 2018). This subsystem is required to explain data indicating that verbal and visual working memory use different resources (Baddeley & Hitch, 1994). Evidently, Baddeley and Hitch (1994) maintain that visual perception and visual imaging share resources that are not employed by the linguistic system. This form of separation is supported by neuropsychological research (Baddeley & Hitch, 1994). The nature of the sketchpad has been mostly inferred from selective interference effects (Baddeley & Hitch, 1994).

Thus, the visual aspect of the imaging system can therefore be tied to whether it is practical to divide the sketchpad into two halves, one of which focuses on information regarding spatial position and the other on visual identity (Baddeley & Hitch, 1994). Such a division would be in line with the development of different neurophysiological systems for processing the visual objects' appearance and spatial placement (Baddeley & Hitch, 1994).

The central executive is an attentional control system and oversees allocating resources with a finite capacity to support both within- and outside-the-working-memory system operations (Engel et al., 20018). Additionally, it has been proposed by Engel et al. (2008) that the central executive facilitates children’s learning, reading, language comprehension, and math during the critical developmental period, which in turn has a direct impact on their performance in university (Du Toit, 2017). Under irregular circumstances, the central executive engages in control-type operations and dual-task processing (Vallat-Azouvi et al., 2009).

Researchers have found that when subjects' attentional control is fully engaged, individuals tend to reach an optimal level of performance, while when it is not, individuals tend to perform poorly (Adam & Vogel, 2017). According to research, focusing on one's attention is critical to the differences in working memory among individuals (Cowan, 2001; McElree, 2001). It also suggests that the ability to expand one's attentional capacity can increase with practice (Verhaeghen & Basak, 2005; Verhaeghen et al., 2004).

Moreover, dual-task processing is said to be a main function of the central executive (Vallat-Azouvi et al., 2009). Furthermore, the question of whether the ability to change retrieval techniques is represented in random gene ration has been investigated (Baddeley, 1996). Secondly, Baddeley's (2017) study concentrated on the central executive's ability to selectively concentrate on one input while blocking the disruptive effects of others. Lastly, the ability to keep and alter information in long-term memory, as shown by tests of working memory span, has also been evaluated (Baddeley, 1996).

Having established Baddley and Hitch's (1994) theoretical model as well as the definition of working memory, it is important to discuss the differences and similarities between the constructs of working memory and metacognition. Whilst completing or performing an activity, the working memory of an individual is used to store and process information during the complex task (Freeman, 2017). Although metacognition (MC) involves introspection and evaluation of cognition, WM involves a sophisticated manipulation of the information on the mental blackboard (Georghiades, 2004; Flavell, 1979; Paris & Winograd 1990). Another line of thought on the relationship between MC and WM demonstrates that both MC and WM are dependent on the control mechanisms that participants use to manage their actions. If an executive failure occurs, then both abilities may suffer (Adam & Vogel, 2017).

Livingstone (2003) maintains that the concept of MC refers to the process of monitoring and planning one's thoughts. It involves being able to understand the various processes involved in performing a task, as well as identifying the strategies that will allow one to complete a given task (Georghiades, 2004). Thus, these two constructs share similarities with regard to cognitive processes, however, they differ with regards to the way in which complex tasks are carried out (i.e., strategies, processing, storing, and monitoring) (Tariq & Noor, 2012).

Having discussed some of the similarities and differences between the two constructs, the next section will discuss the aspects of working memory. Thus, it has been maintained that an optimally functioning working memory helps individuals carry out complex tasks and activities with a focus on learning, reasoning, and understanding (Jehangir, 2020). It is also closely linked to other cognitive processes such as attentional control and executive function (Vallat-Azouvi et al., 2012). Executive function refers to the ability to manage and keep track of actions and thoughts related to a given task (Jehangir, 2020). Attention is focused on the ability to keep track of goals and keep data (Vallat-Azouvi et al., 2012). On the other hand, storage is concerned with preserving task information (Vallat-Azouvi et al., 2012).

Short term memory is related to the storage component of working memory. Thus, the term storage capacity or short-term memory (STM) is also used to describe the type of information that an individual can store for a specific period (Jehangir, 2020). It is referred to as passive storage, which is the information that is available for a limited amount of time (Vallat-Azouvi et al., 2012). On the contrary, active storage is the type of information that is required for a given task (Jehangir, 2020). The ability to retain working memory capacity is a vital component of cognitive control and executive function (Jehangir, 2020). Short term memory (STM) is related to the central executive otherwise known as the attentional control system, which has a limited capacity to support both within- and outside-the-working-memory system (Baddley & Hitch, 1994; Engel et al., 2018).

The long and short-term memory components are regarded as vital in reading comprehension (Hassanbeigi et al., 2011). Such components play a crucial role in the reader's ability to interpret, manipulate, and store information in WM while processing the text (Hassanbeigi et al., 2011). Although, the reader needs to construct a cohesive representation of the text at the same time (Hassanbeigi et al., 2011). Thus, by keeping track of all the details, by using their WM, and referring to their prior knowledge, the reader can decipher what is going on (Hassanbeigi et al., 2011). All these strategies require the student to have metacognitive awareness in order for their WM to be functioning at an optimal level (Hassanbeigi et al., 2011).

Previous Studies

Furthermore, according to studies (Jehangir, 2020; Pollard & Courage, 2017), when performing complex multitasking, the brain is less activated. However, as the difficulty of the

task increases, the brain's recruitment of additional neural resources is seen (Pollard & Courage, 2017). Given the fact that short-term memory refers to information that can be accessed only for a limited amount of time. It was vital to include STM as when this component is being consciously thought of and rehearsed at that given moment, information is remembered (Cowan, 2001). Thus, when students are learning, they are activating their STM by absorbing new information and using metacognitive strategies to transform this information into long term memory (Cowan, 2001).

Individuals rely on control mechanisms that are dependent on metacognition and WM, in order to monitor and manage their actions. It is also important to note that these strategies are not always implemented properly. To date, there are few studies on whether people can effectively monitor and implement working memory strategies (Schwartz, 2006; Thomas et al., 2012; Touron et al, 2010). If so, this suggests that they can also monitor the functioning of their working memory (Thomas et al., 2012). A study that investigated the working memory processes of older and younger adults found that younger individuals could accurately and metacognitively monitor their own working memory (Touron, Oransky, Meier, & Hines, 2010).

The ability to control and monitor the behaviour that influences an individual's WM on tasks can be used to guide strategy implementation and strategy recognition, is said to be regulated by metacognition (Touron et al., 2010). Thus, the literature shows that working memory differences are related to strategic behaviour in individuals. For instance, those who used higher cognitive monitoring techniques and strategies had a higher working memory span (Dunlosky & Kane, 2007; Turley-Ames & Whitfield, 2003). It is also reported that the actions that help guide one's working memory ability are mediated by metacognitive control and monitoring (Touron et al., 2010).

According to Amichetti et al. (2013) the link between regulation of cognition and working memory is related to the ability to calculate the availability of resources for various tasks. The authors noted that online capacity monitoring (the ability of an individual to continuously monitor and encode the arrival of new information) could be a type of working memory function, that can be hindered by the lack of attentional resources (Amichetti et al., 2013). Furthermore, in the study conducted by Adam and Vogel (2017) the authors found that the distinct differences in metacognitive accuracy correlated with the performance of working memory, this indicates that metacognitive monitoring may be vital to receiving a positive result

in working memory, and thus improving their working memory. The authors found that participants' metacognitive judgements predicted the variations in working memory's performance but underestimated the extent to which these errors were experienced (Adam & Vogel, 2017).

The Relationship Between WM and Metacognition

To further understand the relationship between WM and metacognition, the section below explores studies which have investigated this relationship. According to a study conducted by Adam and Vogel (2017) conducted a series of WM and metacognitive awareness experiments with the intention of exploring if participants were able to accurately identify their failures. Only 28% of the participants were able to identify their failures due to external factors, such as the presence of external distractions, as well as the increasing number of mind wanderings. The study also placed a strain on the participants' executive resources. Additionally, instead of focusing on their thoughts, the participants reported their perceived performance (Adam & Vogel, 2017).

The study conducted by Aghdar et al. (2020) sought to determine if working memory and metacognition could help mediate the relationship between academic performance and self-regulation. It revealed that there was a direct and significant relationship between working memory and executive functions, which included cognitive flexibility, active memory, inhibitory control, selective attention, decision making, social cognition, planning, and stable attention. Moreover, there was a significant relationship observed between the variables of metacognition and working memory with academic learning and academic self-regulation ($p=<0.01$) (Aghdar et al., 2020).

The executive function score can be calculated by adding up the scores obtained for cognitive flexibility, active memory, inhibitory control, selective attention, decision making, social cognition, planning, and stable attention, and researchers measured this construct using the Cognitive Abilities Questionnaire (Nejati, 2013). Executive functions significantly correlated with working memory ($r=0.26$, $p=<0.01$); Metacognition significantly correlated with executive functions ($r=0.32$, $p=<0.01$) and significantly correlated with working memory ($r=0.19$, $p=<0.01$); Self-regulated learning significantly correlated with executive functions ($r=0.29$, $p=<0.01$), significantly correlated with working memory ($r=0.30$, $p=<0.01$), and significantly correlated with metacognition ($r=0.32$, $p=<0.01$) (Aghdar et al., 2020). Moreover,

the researchers used structural equation modelling and determined that there is a direct, positive, and significant (p=<0.01) relationship between executive functions and metacognition, as well as between executive functions and working memory (Aghdar et al., 2020).

Moreover, according to Sperling and Follmer (2016) executive functions can predict an individual's self-regulation and metacognition. Moreover, studies have revealed that the executive functions of individuals can predict the use of metacognitive techniques and promote diversity within academic self-regulatory processes. Furthermore, they also concluded that the relationship between self-regulation learning, WM, and executive functions can be mediated by metacognition, as these factors interact with each other (Follmer & Sperling, 2016; Garner, 2009).

1.2.2 The Working Memory Questionnaire

The WMQ in this study will be used to assess the effects of daily failures of working memory on their academic achievement. The WMQ was created by Vallat-Azouvi et al. (2012) which focused on the concerns of daily failures in working memory. The Working Memory Questionnaire (WMQ) (Vallat-Azouvi et al., 2012) which utilises this concept of daily failures of working memory, used Baddeley and Hitch (1994) theoretical model for the construction of the WMQ tool. Therefore, as the researcher is assessing daily failures of working memory, just as Vallat-Azouvi et al. (2012) did in their study. The objective of the WMQ is to provide thirty questions in three different domains (ten each) (Vallat-Azouvi et al., 2012). These were presented in a pseudo-random order to avoid any potential response bias. The questions were rated using a five-point Likert scale, ranging from zero ("no problem at all") to four ("very severe problem in everyday life") (Vallat-Azouvi et al., 2012). There were three subscores for each of the domains (ten questions in each domain), and the total score is computed (a maximum score of 40 for each subscale is avaliable). Higher scores indicated more complex problems, difficulties, or complaints (Vallat-Azouvi et al., 2012).

Within the WMQ there are three domains (Vallat-Azouvi et al., 2012). Short-Term Storage is the first domain. It is designed to test the ability to store information for a specific period (Vallat-Azouvi et al., 2012). This also included questions about mental calculation and written text comprehension (for example, "Do you have problems with remembering sequences of numbers, or "do you have problems when you have to note down a telephone number?") (Vallat-Azouvi et al., 2012). The second domain is focused on attention, with questions about

mental fatigue, dual-task processing, and distractibility (for example, “Do you need to make an effort to concentrate in order to follow a conversation in which you are participating with many other people?”) (Vallat-Azouvi et al., 2012). The third domain is on executive functions, such as planning, making decisions, or shifting (for example, “When you are carrying out an activity, if you realise that you are making a mistake, do you find it difficult to change strategy?”) (Vallat-Azouvi et al., 2012).

Having established the WMQ and its elements, it’s important to consider what factors may be influencing daily failures of WM. Various factors can affect the performance of working memory (Jehangir, 2020; Vallat-Azouvi et al., 2012). Some of these include the age, gender, environment, and personality (Jehangir, 2020; Vallat-Azouvi et al., 2012). Working memory is highly predictive of an individual's performance on various cognitive measures, including their language abilities, abstract reasoning, mathematics, and fluid intelligence (Jehangir, 2020; Pollard & Courage, 2017). Furthermore, cultural upbringing, as well as schooling and training experiences, can also help with the development of an individual’s working memory (Jehangir, 2020).

Many students suffer from working memory failures, these issues are related to negative memory outcomes (Adam & Vogel, 2017; De Jong, 1998; Kane et al., 2007; Perciavalle et al., 2016; Rapport et al., 2008; Rapport et al., 1999; Teasdale et al., 1993). According to researchers, working memory failures persisted even after the participants claimed they were on task (Adam & Vogel, 2017). Thus, revealing that participants are usually not aware of their failures in working memory. It's believed that researchers may have minimised the frequency of working memory failures, particularly if failures in working memory are associated with being off track, task-related interference, or digress from one’s work as a result of external distractions such as talking, or loud noises (Adam & Vogel, 2017). Performing decrements can become more severe when observers are not aware of mind-wandering incidents, or external distractions (Adam & Vogel, 2017). This can happen when students become completely disinterested in the task at hand (Adam & Vogel, 2017).

It has been known that mind wandering can have an impact on complex tasks, and thus, the ability to focus on given tasks (Teasdale et al., 1993). In a study conducted by Kane et al. (2007) it is revealed that individuals with low attentional control and capacity tend to experience mind-wandering whenever they perform or engage in real world tasks which prove to be challenging. Thus, students may be unaware of their failures in working memory when

they are distracted and may be inattentive to both primary and secondary task demands (Teasdale et al., 1993). These entail memorising items, and students noticing which items they have remembered (Adam & Vogel, 2017).

Furthermore, a minor interruption or thought that's not related to the task at hand could lead to the loss of the stored information, or why a failed calculation attempt might occur (Alloway, 2006). Growing evidence suggests that students poor working memory skills (otherwise presented as daily failures in WM) can lead to a variety of problems, such as poor performance on mathematical and arithmetic word problems for students (Alloway, 2006). In addition to these, other deficits arise such as an impaired recall on both arithmetic and mathematical working memory stimuli, as well as an increased likelihood of intrusion errors (Alloway, 2006).

These daily failures of WM and the variety of symptoms in which students at university report, directly influence and can have a detrimental impact on their academic achievement (Tariq & Noor, 2012). Thus, students with low attentional control and capacity may be experiencing mind-wandering in class and missing out on vital information (Kane et al., 2007). Moreover, task-related interference or external distractions such as talking, or loud noises may be one of the reasons that students' attentional capacity falls short. Although, they may be disinterested in the task at hand, as it may be too complex (Adam & Vogel, 2017). Therefore, daily failures in WM in students at university can lead to poor performance and poor academic achievement (Adam & Vogel, 2017).

1.2.2 The Relationship between Daily Failures of Working Memory and Academic Achievement

One of the most common obstacles to academic success is the lack of proper attention and focus. This is because focusing on one's academic goals requires constant effort and discipline (Hassanbeigi et al., 2011). Unfortunately, there are many distractions that can prevent students from achieving their goals (Hassanbeigi et al., 2011). Alloway and Alloway (2010) maintain that WM is correlated to self-discipline, which may affect academic achievement. Given the copious number of students in lecture halls in governmental higher education intuitions in South Africa, self-discipline is essential for students' academic performance.

However, in contrast to students achieving their goals and maintaining academic achievement, it is vital to discuss why students may not be achieving their goals or failing at university, hence, they may be experiencing daily failures in working memory. Working

memory is connected to almost all the fundamental cognitive processes (Fougnie et al., 2015; Tariq & Noor, 2012). Fougnie et al. (2015) have stated that a few examples of the cognitive processes with strong connections to working memory, are attentional control, problem solving, language, logic, and awareness. Although, in this study, the present obstacles to academic attainment for university students are interlaced with daily failures in working memory (Vallat-Azouvi et al., 2012).

Students with daily failures in working memory may take considerably longer to memorise new information that is presented to them at school or at university (Freeman et al., 2017; Tariq & Noor, 2012; Vallat-Azouvi et al., 2012). Hence, students may quit the activity out of annoyance and disappointment in themselves (Tariq & Noor, 2012). Complex tasks such as comprehension, learning, problem solving and reasoning, are all tasks which require the individual to be able to actively store new information in their mind (otherwise known as short term memory), therefore, these complex tasks all require efficient working memory processing (Tariq & Noor, 2012; Freeman et al., 2017; Vallat-Azouvi et al., 2012).

Working memory is said to be and act as a bottleneck for learning, this is due to the incremental nature of learning, that is gradually being built over time (Hassanbeigi et al., 2011). Therefore, disruptions such as an inability to retain information, or poor attentional control or capacity, which is a direct result of poor working memory can jeopardize academic achievement (Hassanbeigi et al., 2011). One of the most common reasons why students fail to achieve their academic goals is due to their lack of attention, studying, incomplete assignments, or not being able to properly concentrate in exams or tests (Hassanbeigi et al., 2011). The effects of test anxiety on students' performance are related to the attentional domain (Hassanbeigi et al., 2011). According to a view on test anxiety by Wine (1971) individuals tend to focus on task-irrelevant cues instead of task-relevant ones. Hence, their performance is affected by their attention being divided between relevant and irrelevant tasks and stimuli (Hassanbeigi et al., 2011).

Having established why students may be failing at university, it is important to discuss strategies in which they can improve their academic performance. According to Grabe (2005) students can benefit from the various processes involved in reviewing and taking notes. The former is regarded as an external storage function, while the latter is an encoding function (WM domains). Thus, the cognitive activities that are involved in creating a personalized record of a lecture are said to have the most beneficial effects (Grabe, 2005). It has been suggested,

however, that students should perform better when it comes to studying their own materials (Hassanbeigi et al., 2011).

Furthermore, students often encounter the gap between the evaluation (going over new information) and the presentation of information (learning about new information) (Hassanbeigi et al., 2011). Having an external record (such as notes) to review during this period can help students with keeping track of their learning and to review after class (Hassanbeigi et al., 2011). It is no surprise that lecture notes are very useful as they allow students to assess their performance later (Hassanbeigi et al., 2011). There is evidence supporting the notion that storing and encoding functions of note taking during class can be beneficial (Hassanbeigi et al., 2011).

Having established strategies to improve WM and thus, academic achievement, this section will now discuss studies which have investigated these constructs. Abu-Rabia (2003) stated that significant correlations occurred between the construct of working memory and academic achievement (reading and writing), in English as a second language. The findings in the study by Abu-Rabia (2003) were consistent with the findings of Swanson and Berninger (1996) as significant correlations were found in their study between the construct of working memory and reading, as well as between working memory and writing ability; hence, the study supported the hypothesis that under certain conditions, the performance of working memory and text generation (writing and comprehension) can improve, as the correlation is positive and significant ($p=<0.01$).

Moreover, according to Alloway and Alloway (2010) working memory is a strong predictor of academic success. Working memory problems can lead to failures in various tasks at university, such as remembering instructions and keeping track of one's progress in difficult situations (Hassanbeigi et al., 2011). Daily failures in WM can also cause learning deficits and make it difficult to perform daily learning activities (such as critical thinking, reflection, or problem solving) (Alloway & Alloway, 2010; Hassanbeigi et al., 2011).

1.2.3 Tertiary Education Within the South African Context

One of the main differences between education and learning is that the former aims to provide the skills that will allow students to continue their learning after leaving school (Cowan, 2014). Academic achievement in the South African context is usually measured in terms of what percentage students have received for each module, and what their academic average for the year or degree is; this being aside from graduation rates (Živčić-Bećirević et

al., 2017; Gibb et al., 2002). It has been indicated that university student's marks reflect their motivation to study, as well as a reflection of their academic efficacy and mental ability (Živčić-Bećirević et al., 2017). Student's perceptions of their abilities, and their cognitions are vital components in whether they will reach their required level of academic achievement (Živčić-Bećirević et al., 2017).

Having established the academic achievement within the context of South Africa, this section discusses higher education institutions. As higher education institutions entrance requirements increase, it has become essential to recognise factors, as well as issues which promote, decrease, and link to academic achievement (Gibb et al., 2002; Živčić-Bećirević et al., 2017). The goal of higher education is to ensure that all students succeed (Gibb et al., 2002; Scott, 2018). Unfortunately, there are still no signs of concrete steps being taken by policymakers and institutional leaders toward making student success a priority (Scott, 2018). In South Africa, only around half of the students who enter university in either distance or contact mode graduate (Scott, 2018). According to educators and politicians, institutions are failing to provide the necessary support and resources to help students develop the skills and knowledge they need to succeed in their future careers (Du Toit, 2017).

Access to higher education is a major challenge that South Africa faces (Scott, 2018). In developing countries, where life chances are heavily dependent on attaining educational attainment, it is especially important that the mission of higher education is carried out properly (Scott, 2018), as there is already a shortage of skilled and advanced individuals. The increasing complexity of today's world and the need for effective and contextualized learning are forcing educators and policymakers to rethink how they teach and how they support students (Du Toit, 2017). In order to deal with the rapid evolution of the world, educators and policymakers must develop strategies and methods that are geared toward equipping students with the necessary adaptive competence (Du Toit, 2017).

Thus, the goal of student success as stated in the Council of Higher Education - CHE's (2013) is to enhance the learning experience for all students and increase the number of graduates who have social, professional, and personal attributes (CHE, 2013). Thus, the end goal is to ensure that all students graduate successfully and become metacognitive learners (Du Toit, 2017). This concept is especially important in developing countries, such as South Africa, where access to higher education is very limited (Scott, 2018). Therefore, educational institutions are responsible for providing their students with lifelong learning skills (Du Toit,

2017). By continuously engaging in education, students can develop a deeper understanding of their own thinking and become more aware of their own cognition (i.e., metacognitively aware) (Du Toit, 2017).

Unfortunately for students who do not graduate, or who do not obtain a successful completion, their education has little value in the corporate world (i.e., they do not hold a degree) (Scott, 2018). Therefore, student success and hence, academic achievement and attainment, can have a significant impact on the country's overall development (Scott, 2018).

1.2.4 Conceptualising Academic Achievement

An academic achievement is a performance metric that shows how far a person has come in achieving their goals, which are typically focused on various activities in school, university, or other educational settings (Gibb et al., 2002). It is a vital part of every person's life who attends a higher education institution (Steinmayr et al., 2014). Academic achievement involves different criteria such as declarative and procedural knowledge that an individual can acquired through their education (Steinmayr et al., 2014); grades and performance on tests (Du Toit, 2017); and cumulative indicators of academic achievement such as educational degrees and certificates (Steinmayr et al., 2014).

In addition to academic performance as a performance metric, the nation’s performance needs to be addressed. The results of South Africa’s academic performance are used to inform various educational policy decisions and improve the country's educational system (Steinmayr et al., 2014). These analyses are also used to identify areas of weakness and strengths in the nation's educational system (Steinmayr et al., 2014). One of the most frequently studied variables in education and psychology is the grade point average (GPA) (Steinmayr et al., 2014). However, in this study percentages are utilised, as South Africa does not use a GPA system (Steinmayr et al., 2014). Therefore, the task of higher education institutions is to make learning more genuine, applicable, and contextualised so that students are prepared to handle difficulties both within and outside of the lecture halls (Du Toit, 2017).

Having established that academic achievement is a nation’s performance, the section below will discuss skills and abilities that individuals learn by attending university, and therefore apply to everyday situations, as well as to the working world. Thus, real-world issues demand more advanced abilities and expertise to solve them. As a result, adaptive skills are needed to help people use their knowledge and abilities in new contexts (Du Toit, 2017). To navigate this rapidly changing environment and apply current knowledge to new situations and

issues, an individual's adaptive competence must be encouraged (Du Toit, 2017; Gibb et al., 2002). Thus, academic achievement is a complex concept that encompasses various learning domains (Steinmayr et al., 2014). Since the field is wide-ranging, the definitions of academic achievement vary depending on the various indicators used to measure them (Steinmayr et al., 2014). An individual's academic achievement determines whether they can pursue higher education (Steinmayr et al., 2014). Based on the degree that they have attained, their vocational career path after graduating can also be influenced by academic achievement (Steinmayr et al., 2014).

In conclusion, university students' academic achievement has been correlated with student's knowledge of cognition, and regulation of cognition (Amzil & Stine-Morrow, 2013; Hammann & Stevens, 1998; Sperling et al., 2004; Young & Fry 2008). Furthermore, it has been shown that university students' academic achievement is linked to working memory (Abu-Rabia, 2003; Alloway & Alloway, 2010; Swanson & Berninger, 1996), and thus there may be a correlation between academic achievement and daily failures of working memory in students. Moreover, the role of metacognition lies within the university students' capability of understanding their own cognition and successfully regulating it (Reisoğlu et al., 2020; Schraw and Dennison, 1994; Schraw & Moshman, 1995), which in turn directly influences their daily failures of working memory and their academic achievement. This will be further elaborated on in the rationale.

1.3 Rationale

Modern understanding of this construct indicates that individuals with high levels of metacognition are capable of regulating, evaluating, distinguishing, and reorganising their thoughts (Georghiades, 2004). However, in this study Brown's (1978) framework is the focus as it contains two distinct components of metacognition, namely the individual's regulation of cognition and the knowledge concerning cognition, which directly relates to the two categories found within the Metacognitive Awareness Inventory (MAI) instrument (Schraw & Dennison, 1994).

Given that metacognition and WM are closely linked (Komori, 2016), and as a result individuals with better metacognition seem to have a better WM (Coutinho, 2007). Furthermore, metacognition and WM have also been found to separately correlate with the capacity that students have to achieve higher marks (Tariq & Noor, 2012). Thus, from the literature it is evident that these three variables have been established individually, but the

specific question of the correlations between them has not been addressed. Therefore, it is the inclusion of all three variables in this study which adds novelty. Given the associations between these variables indicated in the literature, this study aims to explore whether daily failures of working memory and metacognition are linked to academic achievement on a sample of students in South Africa who are engaging with blended learning, which imposes more demands on their capacities such as attention, processing rate, and memory (Tariq & Noor, 2012; Freeman et al., 2017; Vallat-Azouvi et al., 2012).

The link between student academic achievement and metacognition has become the centre of attention in academic research, it has also contributed to the development of higher education policies (Howlett et al., 2021). Thus, academic achievement in students at university can be influenced by metacognition, from both the knowledge they hold about their cognitive processes at university, as well as the regulation of their cognition (Romainville, 1994). Therefore, it is important to question how much of a university students' capacity to know their own cognition and to regulate it successfully has been challenged, as well as whether they encounter daily failures in working memory. Thus, if there is a link between the construct of working memory and academic achievement there may also be a link between the daily failures of working memory and academic achievement in university students.

1.4.1 Research Aims

The purpose of this study was to investigate the associations between metacognitive capacity and daily failures of WM in university's students' academic achievement.

1.4.2 Sub-Aims

(1) Describe the demographic characteristics of the sample.
(2) Describe the participants performance on the Metacognitive Awareness Inventory (MAI) questionnaire regarding the categories of regulation of cognition and knowledge of cognition.
(3) Describe the prevalence and characteristics of daily failures of working memory in terms of the participants reports on the short-term storage, attention, and executive dimensions of the Working Memory Questionnaire (WMQ).
(4) Explore the correlation between academic achievement in university students and the subcategories of metacognition as measured by the MAI.
(5) Explore the correlations between academic achievement in university students and the domains of daily failures of WM as measured by WMQ.

(6) Determine if there is a correlation between subcategories of metacognition as measured by the MAI and domains of daily failures of WM as measured by the WMQ.

1.5.1 Research Questions:

1) Do the subcategories of Regulation of Cognition in the Metacognitive Awareness Inventory (MAI) and the short-term storage, attention and executive domains of the Working Memory Questionnaire correlated?
2) Do the relationships between the subcategories of metacognition as measured by MAI, and the domains of daily failures of working memory as measured by the WMQ predicting variations in academic achievement?

1.5.2 Hypotheses

1) H0: There is no statistically significant relationship between the subcategories of regulation of cognition in the Metacognitive Awareness Inventory and the domains of the Working Memory Questionnaire.
2) H0: There is no statistically significant relationship between the variables and therefore, no prediction of academic achievement.

2. Chapter 2: Methods

This chapter will introduce the various methods used in the study. It will begin by describing the design and procedure of the research, as well as the sampling strategy and the measurements that were used to collect the data. The chapter also covers the statistical analyses that were performed, as well as the ethical considerations involved in the study.

2.1 Research Design

The design of the study was a quantitative non-experimental, correlational, cross-sectional study (Field, 2013). The research design was quantitative in nature, as the data obtained from the study was analysed in number units and is non-experimental as there was no manipulation of variables (Thomas, 2013). A cross-sectional design was used in the study, as data was only collected from the participants once (Rubin & Babbie, 2016). Furthermore, this study is correlational as it established whether there were statistically significant correlations present among the variables under investigation (Thompson et al., 2005).

2.2 Sample and Sampling

Convenience sampling was the method use to obtain the sample for this study (Field, 2013). The participants were university students. All full-time registered students for the 2022 academic year at the University of the Witwatersrand were invited to participate. The sample included 190 students. Participants who dropped out of the survey or who did not fill out either the MAI (Schraw & Dennison, 1994) or WMQ (Vallat-Azouvi et al., 2012) were removed from the database (N= 64). Furthermore, participants who failed to provide their last three marks were removed from the database (N=25). Details on the demographic characteristics are described in the results chapter.

2.3 Procedure

Ethical clearance was obtained was obtained from the Human Research Ethics Committee (HREC Non-Medical) a division of the University of Witwatersrand. Protocol number: MAPSYC-22-06 (see Appendix 1). Upon receiving ethical approval, the researcher received permission from the university Registrar in order to distribute the invitation via email blast to the student population at Wits (see appendix 2). Once ethical approval was granted from both the HREC and the Registrar; the researcher piloted both questionnaires, to make sure that the questionnaires took no longer than twenty-five minutes to complete. Five postgraduate students in the Psychology Department agreed to voluntarily fill out the questionnaires for this pilot stage.

Participant recruitment was conducted by email via the distribution lists, following the Registrar's guidelines, whereby the researcher shared the invitation and survey link to participate in the study (see Appendix 2). If the student wished to participate in the study, they clicked on the survey link which then diverted them to the homepage of the survey which obtained the information sheet (see Appendix 3). The information sheet defined the voluntary and confidential nature of the research, the study's aims, the researcher's and supervisor's contact details, the duration of the assessment, as well as the right to withdraw at any point in the study or refuse to participate in the research.

Each participant completed the demographic questionnaire, the Metacognitive Awareness Inventory questionnaire (MAI) (Schraw & Dennison, 1994), and the Working Memory Questionnaire (WMQ) (Vallat-Azouvi et al., 2012). The data collection procedure was carried out over a period of two months. Participants' responses were stored on SurveyMonkey's secure cloud until the eight weeks were complete, as well as coded onto an excel file on the researcher's computer.

2.4 Instruments

All data that was gathered using Survey Monkey. On this platform participants were asked to complete a questionnaire which entailed three sections, which are all self-assessed questionnaires.

2.4.1 Demographic Questionnaire

A demographic questionnaire (see Appendix 4) was developed specifically for this study. This consisted of questions such as age, gender, year of study, degree that the participant is currently completing, last three highest marks obtained in the last block (or semester), and a true or false question pertaining to if they are satisfied with their academic performance, as well as how many languages the participant speaks (limit of five languages).

2.4.2 Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994)

The participants were asked to complete the MAI (Schraw & Dennison, 1994), the questionnaire is not included in the appendix due to copyright. The Metacognitive Awareness Inventory (MAI) is a 52-item inventory to assess metacognition (Schraw & Dennison, 1994). Items are categorised into 8 subcomponents (also known as subscales) contained within 2 broader categories. Permission has been obtained to use the MAI in the research report. The first is knowledge of cognition, within this category there are three subcomponents (also called subscales) which fall under it, namely, declarative knowledge, procedural knowledge,

conditional knowledge (Schraw & Dennison, 1994). The second is regulation of cognition, within this category there are five subcomponents (also called subscales) which fall under it, namely, planning, information management strategies, monitoring, and debugging strategies (Schraw & Dennison, 1994). These two broader categories of metacognition are supported by Brown (1978).

Schraw and Dennison (1994), developed the MAI to assess the regulation and knowledge of metacognitive knowledge. The authors refer to these two components as the regulation of the cognition factor and knowledge of cognition. The 52 questions in the MAI are designed to explore the various aspects of metacognitive knowledge. They found support for the idea that the regulation and knowledge of cognition are related as had been previously suggested in the research by Brown (1987).

Schraw and Dennison (1994) then went on to test the convergent validity of the MAI by comparing its scores with those of other measures that are related to metacognitive aspects, such as the ability to monitor test performance and pre-test monitoring ability, as well as actual test performance. They found no significant relationship between the MAI and the monitoring accuracy, or between the monitoring accuracy and pre-test judgements. Although, knowledge of the cognitive factor of the MAI was associated with higher test performance. Additionally, knowledge of cognition was related to the MAI's performance, and the pre-test judgments were positively associated with the test performance (Schraw & Dennison, 1994).

The MAI's Cronbach's Alpha was established at 0.91 for items loading on each factor, Cronbach's Alpha of 0.95 for the entire instrument, thus indicating a high internal consistency reliability, as well as a strong correlation $r=0.54$, significant at $p=< 0.05$ (Schraw & Dennison, 1994). The two factors accounted for 65% of variance (Schraw & Dennison, 1994). Hence, bringing factor one to all items with high loadings on Knowledge of Cognition (3 subscales), and factor two to all items with high loadings on Regulation of Cognition (5 subscales) (Schraw & Dennison, 1994).

Participants answered the questions on a five-point Likert-type scale as it yields stronger correlations between the two abovementioned categories, ($r=0.75$, $p< 0.01$) (Sperling et al., 2004). The Turkish version of the MAI revealed the internal consistencies to be .95 for the instrument, and for the subscales .93-.98. (Akin et al., 2007). It has been indicated by Dennison (1997) that the MAI has a high internal consistency of the two subscales, namely, regulation of cognition, and knowledge of cognition. Internal consistency is said to range

between r = .90 - r = .95 (Dennison, 1997). The Metacognitive Awareness Inventory (MAI) is used frequently by academics (Akin et al., 2007; Kallio et al., 2017; Mentz et al., 2014; Öz, 2016; Rajcoomar, 2019). The local use of the MAI in the last decade has become more frequent (Du Toit, 2017; Mentz et al., 2014; Rajcoomar, 2019; Van der Walt, 2014).

In Zhang's (2010), study the researcher confirmed the validity and reliability of the instrument. The aim of this study was to analyse the predictability of metacognition based on the self-rated abilities. Furthermore, Philippou and Panaoura (2003) used the MAI inventory to study the development of children's metacognitive abilities in mathematics. The main aim of the study was to examine the development of the instrument as well as the validity of the scale. A confirmatory factor analysis revealed that the second-order structure represented metacognition, whereas the knowledge of cognition and regulation of cognition was represented by two first-order factors.

The abovementioned studies have explored metacognition and metacognitive awareness in South Africa, across different age groups, and in different settings; thus, demonstrating the MAI has external validity and is generalisable to the South African population (Du Toit, 2017; Mentz et al., 2014; Rajcoomar, 2019; Van der Walt, 2014). In the MAI scale, item 16 was adjusted to suit the researcher's sample, as the researcher could not use the word teacher in a university student questionnaire. Hence, the word teacher was changed to lecturer.

2.4.3 Working Memory Questionnaire (WMQ) (Vallat-Azouvi et al., 2012)

The participants were asked to complete the WMQ (Vallat-Azouvi et al., 2012) the questionnaire is not included in the appendix due to copyright. This behavioural self-assessment questionnaire consists of 30 questions which are evenly divided into three different domains containing ten questions (Vallat-Azouvi et al., 2012). These questions follow no order so that response bias will be minimised (Vallat-Azouvi et al., 2012). No permission was needed to use the WMQ in the research report.

Furthermore, each section focuses on short-term storage, attention, and executive characteristics of working memory (Vallat-Azouvi et al., 2012). Each of the questions are rated on five-point Likert-type scale from 0 – "not at all", 1 – "a little", 2 – "moderately", 3 – "a lot", 4 – "extremely" (Vallat-Azouvi et al., 2012, p.6). In each three domains sub-scores are generated, producing a highest score of 40 for each, as well as the total score 120 (Vallat-

Azouvi et al., 2012). Hence, higher scores on the questionnaire will relate to daily failures of working memory, and thus more complaints (Vallat-Azouvi et al., 2012).

The goal of the WMQ is to identify the various types of difficulties that people have in working memory (Dodaj et al., 2017). It can be used to evaluate difficulties in recalling verbal information and numerical information, struggles in executive functioning and attention. The statements on the subscales of working memory covers the various types of difficulties that people have in recalling verbal information (e.g., "Do you have difficulty understanding what you read?"), or numerical information (e.g., "When you pay cash for an item, do you have difficulty in realizing if you have been given the correct change (Vallat-Azouvi et al., 2012).

Furthermore, working memory difficulties relate to and include retention of verbal information, textual comprehension (e.g., "Do you find it difficult to remember the name of a person who has just been introduced to you?") (Vallat-Azouvi et al., 2012), or difficulties in processing information, and recalling numerical information ("Do you have problems with remembering sequences of numbers, for example, when you have to note down a telephone number?") (Vallat-Azouvi et al., 2012)

The various statements contained within the subscale of executive functioning are related to difficulties concerning executive functioning such as making decisions, organising, and planning (e.g., "Do you feel that you are very slow to carry out your usual activities" and "Do you have difficulty in organizing your time with regard to appointments and your daily activities?") (Vallat-Azouvi et al., 2012). The various types of difficulties that people experience in focusing are also discussed in the subscale of attention (Vallat-Azouvi et al., 2012). These include difficulties in performing activities in a chronological order (e.g., "Do you find it difficult to carry out an activity with chronological steps (cooking, sewing, DIY)?") (Vallat-Azouvi et al., 2012), and in focusing (e.g., "Do nearby conversations disturb you during a conversation with another person?") (Vallat-Azouvi et al., 2012).

The questionnaire was originally developed to assess everyday life problems in brain injured patients. However, this questionnaire has been administered to healthy participants (Vallat-Azouvi et al., 2012) and has shown to be reliable. Furthermore, Cronbach's alpha was established at .89 for the normative sample indicating a good internal consistency reliability (Vallat-Azouvi et al., 2012). The aim of Arjmandnia's et al. (2017) study was to analyse the psychometric properties of the WMQ. The results of the factor analysis revealed that certain items have an appropriate factor load, except for items 6 and 29 (Arjmandnia et al., 2017). The

Cronbach alpha coefficient was .89 (Arjmandnia et al., 2017). Furthermore, the researchers concluded that WMQ is a valid and reliable instrument to assess working memory (Arjmandnia et al., 2017).

The objective of Guariglia et al. (2020) study was to provide a psychometric analysis of the WMQ in Italy. Data was collected from 697 healthy individuals aged between 18 to 88 years old. The results of the tests revealed that the instrument was significantly correlated with various paper-and-pencil assessments that tested executive functions, attention, and working memory (Guariglia et al., 2020).

The internal validity of the Italian variant of the WMQ was high, as the domains that were related to its total score had strong correlations (Guariglia et al., 2020). WMQ total score [$F(4, 19)= 5.31$, $p = .001$, $\eta 2 =.030$] and on the three domains [memory storage: $F(4, 19)= 3.89$, $p = .004$, $\eta 2 = .022$; attention: $F(4, 19)= 7.07$, $p = .001$, $n2 = .040$; executive functions: $F(4, 19)= 2.85$, $p = .023$, $\eta 2 = .017$]. In addition, the instrument had a high concurrent validity as its performance was significantly correlated with other cognitive assessments that were focused on attention, working memory, and reasoning (Guariglia et al., 2020). In Guariglia's et al. (2020) study they assessed EF based off the Corsi Block-Tapping test (CBT; Corsi, 1972; Monaco et al., 2013; Piccardi et al., 2013), and Raven's Colored Progressive Matrices (Raven, 1938; Raven 1986). However, it did not correlate with executive functions (planning, attentional control, cognitive inhibition, problem solving, monitoring, and cognitive flexibility).

With regards to the local use of the WMQ, there has only been one research study conducted in which the WMQ has been utilized (Verkijika, 2015). The WMQ, however, has not been adapted to accommodate the South African population, as no additional versions or translations of the scale are available in Zulu, Xhosa, Afrikaans, or Sepedi.

2.5 Data Analyses

Metacognition was assessed using MAI (Schraw & Dennison, 1994) of which the data of which was interval in nature. Daily failures in working memory were assessed using the WMQ (Vallat-Azouvi et al., 2012) of which the data of which was interval in nature. Demographic characteristics was assessed using a self-developed questionnaire, of which data was a mixture of nominal, ordinal and interval in nature.

The researcher ran descriptive statistics on the age, race, gender, year of study, degree that the participant is currently completing, and the number of languages participant speaks on

the Statistical Package for the Social Sciences (SPSS) (Field, 2013). This yielded results that included the mean, mode, median, range, kurtosis, and skewness (Field, 2013).

Descriptive statistics were analysed on the MAI as well as the sub-scale data on knowledge of cognition and regulation of cognition, in order to provide a description of how metacognition appears in the sample (Field, 2013). This yielded results that included the mean, mode, median, range, kurtosis, and skewness (Field, 2013). Additionally, the researcher generated graphs from these results to determine if metacognition in sample is normally distributed, is skewed, or has a positive or negative kurtosis (Field, 2013).

The researcher ran descriptive statistics on the WMQ and sub-scale data on the short-term storage, attention, and executive domains, in order to provide a description of how daily failures of working memory appears in the sample (Field, 2013). This yielded results that included the mean, mode, median, range, kurtosis, and skewness (Field, 2013). The researcher generated graphs from these results in order to determine if daily failures of working memory in sample is normally distributed, is skewed, or has a positive or negative kurtosis (Field, 2013).

A Pearson correlational analysis was generated on the variables of academic achievement and metacognition and daily failures of working memory. However, before the correlation was run the researcher checked that all assumptions were met for the Pearson correlation by firstly, ensuring that the dependent variable is measured on a continuous scale, and that the independent variables scale is either interval or ratio (Field, 2013). Secondly, the assumptions of a linear relationship as well as for significant outliers was tested, which was done using a scatterplot graph, a PP-Plot graph, as well as a QQ-Plot graph (Field, 2013). Lastly, the assumption of approximately normally distributed data was done by using the Shapiro-Wilk test of normality (Field, 2013). Moreover, the level of significance for this study for all the above-mentioned variables will be determined at alpha = 0.05 or $p =< 0.05$ (Field, 2013).

The dependent variable (academic achievement) is measured on a continuous scale, and the independent variables (metacognition and daily failures in WM) are measured on an interval or ratio scale, thus meeting assumption 1. The scatterplots that were generated were visually inspected in order to assume linearity, and thus meet assumption 2. Furthermore, whilst inspecting the scatterplot, assumption three was met as there were no significant outliers. Furthermore, from the values obtained on the Shapiro-Wilks test of normality for the MAI and each subcategory, the WMQ and each domain, as well as academic achievement variable fell

within the acceptable range to assume normality (p=>0.05), therefore, it can be concluded that the three variables have normally distributed data. These assumptions will be discussed further in the results section.

2.6 Ethical considerations

In this minimal risk study, the researcher upheld all the ethical standards outlined in the Singapore Statement on Research Integrity (Resnik & Shamoo, 2011) and Code of Ethics for Research on Human Subjects of the University of the Witwatersrand: (Wits Human Research Ethics Committee, HREC (Non-Medical), ethical clearance number: MAPSYC-22-06), in order to obtain the necessary approvals and clearances from the University of Witwatersrand's Human Research Ethics Committee (Non-medical). This was followed in order to then get approval and access to be granted by the Dean of Students.

Participants were provided with an information sheet before starting the questionnaire, they were informed that by clicking on the button to start the survey, this was then taken as consent (see appendix 5). As all participants were above the age of 18 years old, hence, they were permitted to participate in the study without getting permission or approval from a guardian or parent. The information concerning the informed consent was provided to participants in the email as well as in the homepage on SurveyMonkey. Preceding the web-based survey, participants were informed about the researcher, they were given the ethical clearance number, the researcher's aim of the study, and the institution's name (see Appendix 5).

Participation was anonymous and confidential. Participants were also informed of their rights to withdraw from the study at any point without any negative consequences. The information form also stated that there would be no risks or benefits arising from participation in this study. Furthermore, if participants had any questions or concerns, they were able to contact the researcher, as well as the researcher's supervisor before, during or after the assessment. Specifically, participation was online, no names of student numbers were requested, and survey identifiers were not activated on SurveyMonkey (Field, 2013; SurveyMonkey, 2023). Moreover, the data collected was stored on a password protected computer and backed up on password protected files on the one drive cloud.

3. Chapter Three: Results

The results review chapter provides a summary on the results obtained from the data collected. The results which are discussed below follow in line with the aims of the study. (1) Describe the demographic characteristics of the sample; (2) describe the participants performance on the Metacognitive Awareness Inventory (MAI) questionnaire regarding the categories of regulation of cognition and knowledge of cognition; (3) describe the prevalence and characteristics of daily failures of working memory in terms of the participants reports on the short-term storage, attention, and executive dimensions of the Working Memory Questionnaire (WMQ); (4) explore the correlation between academic achievement in university students and the subcategories of metacognition as measured by the MAI; (5) explore the correlations between academic achievement in university students and the domains of daily failures of WM as measured by WMQ; (6) determine if there is a correlation between subcategories of metacognition as measured by the MAI and domains of daily failures of WM as measured by the WMQ. The purpose of this study was to investigate the associations between metacognitive capacity and daily failures of WM in university's students' academic achievement.

3.1 Demographic Characteristics of Sample

Aim one, which was to describe the demographic characteristics of the sample, was investigated using descriptive statistics and the results are summarised in Table 1 and 2.

The total sample of participants (N=190) was divided into six age groups and consisted of the following, 18-25 (61.1%), 26-33 (17.4%), 34-41 (12.1%), 42-49 (4.7%), 50-57 (4.7%), 58 and above (0%). The majority of the participants were between the ages of 18 and 25 years (n=116). Therefore, this data shows that there is variation between students age in the university.

Gender in the sample was divided into six groups, namely, (1) females 64.8% (n=130), (2) males 28.4% (n=54), (3) non-binary 2.1% (n=4), (4) transgender (n=0), (5) gender neutral .5% (n=1), (6) none of the above .5% (n=1). From these data, it has been observed that the majority of participants identified as female (64.8%), in comparison to individuals who identify as male, non-binary, transgender, gender neutral, a combination of the above, none of the above, and other.

Table 1

Summary of the Characteristics of the Sample

Variable	Frequency n(%)
Age	
18-25	116(61.1)
26-33	33(17.4)
34-41	23(12.1)
42-49	9(4.7)
50-57	9(4.7)
Gender	
Female	130(68.4)
Male	54(28.4)
Non-binary	4(2.1)
Gender Neutral	1(.5)
None of the above	1(.5)
Number of Languages Spoken	
1 Language	40 (23.1)
2 Languages	53 (30.6)
3 Languages	40 (23.1)
4 Languages	17 (8.9)
5 Languages	23 (13.3)
Year of study	
1st year	29(15.3)
2nd year	38(20.0)
3rd year	29(15.3)
Honours	33(17.4)
Masters	49(25.8)
Ph.D	12(6.2)
Faculty	
Humanities	61 (32.1)
Science	21 (11.1)
Health Science	30 (15.8)
CLM	42 (22.0)
EBE	36 (19.0)
Degree	

Table 1 *Continued.*

Variable	Frequency n(%)
BA	28(14.73)
Sociology	3 (1.6)
Occasional Studies	1(0.5)
Drama Therapy	2(1.1)
Management	5 (2.6)
MBA	5 (2.6)
Speech Pathology	5 (1.1)
Education	6 (3.2)
MMed	3 (1.6)
B.Pharm	2 (1.1)
Psychology	7 (3.7)
Metallurgical Engineering	3 (1.6)
BCom	2 (1.1)
Population Studies	1 (0.5)
Research Psychology	2 (1.1)
Accounting Science	10 (5.3)
Medical Bioethics	2 (1.1)
MBBCh	9 (4.7)
Public Management	2 (1.1)
Mechanical Engineering	5 (2.6)
Physiotherapy	3 (1.6)
Environmental Sciences	1 (0.5)
Civil Engineering	3 (1.6)
Oral Health Sciences	1 (0.5)
Fine Arts	1 (0.5)
PGDBA	1 (0.5)
Information Systems	4 (2.1)
Public Health	1 (0.5)
Acturial Sciences	2 (1.1)
Microbiology	1 (0.5)
Health Economics	1 (0.5)
Business Administration	2 (1.1)
Occupational Therapy	2 (1.1)
Economic Sciences	1 (0.5)

Table 1 *Continued.*

Variable	Frequency n(%)
Medical Science	1 (0.5)
Urban and Regional Planning	3 (1.6)
Property Development and Management	1 (0.5)
Chemical Engineering	7 (3.7)
LLB	2 (1.1)
Film and Television Studies	2 (1.1)
Epidemiology and Biostatististics	2 (1.1)
Media Studies	1 (0.5)
Electrical Engineering	3 (1.6)
H.R	1 (0.5)
Nursing	2 (1.1)
Physics	1 (0.5)
History	2 (1.1)
Entrepeneurship	2 (1.1)
Construction Studies	2 (1.1)
Anatomical Sciences	1 (0.5)
Mining	3 (1.6)
Commerce	2 (1.1)
Organisational Psychology	1 (0.5)
Finance	2 (1.1)
Computer Science	3 (1.6)
Migration and Displacement	1 (0.5)
Architecture	4 (2.1)
MZU01	1 (0.5)
PDBA	1 (0.5)
Biology	3 (1.6)
Property Studies	1 (0.5)
Publishing	1 (0.5)
English	1 (0.5)
Geological Sciences	1 (0.5)
Philosophy	1 (0.5)
Dental Science	1 (0.5)
Biomedical Engineering	1 (0.5)
Physiology	1 (0.5)
PGCE	1 (0.5)
Public Policy	1 (0.5)
Aeronautical Engineering	2 (1.1)

Note. n=190 for the sample. CLM= Commerce, Law, Management, EBE=Engineering and the Built Environment, BA= Bachelor of Arts, MBA= Master of Business Administration, Mmed=

Master of Medicine, B.Pharm= Bachelor of Pharmacy, Bcom= Bachelor of Commerce, MBBCh= Bachelor of Medicine and Surgery, PGDBA= Post Graduate Diploma in Business Analytics, LLB= Bachelor of Laws, H.R= Human Resources, MZU01= The Graduate Entry Medical Programme, PDBA= Postgraduate Diploma Business Administration, PGCE= Postgraduate Certificate in Education.

The year of study was classified according to level of study, namely 1st year (15.3%), 2nd year (20%), 3rd year (15.3%), Honours (17.4%), Masters (25.8%), and Ph.D. (6.3%). These data suggest that Masters students were most willing to complete the study (25.8%). Whilst the fewest responses came from individuals who were completing their Ph.D. (6.2%).

Moreover, there were six faculties of registration, namely, (1) Humanities; (2) Science; (3) Health Science; (4) Commerce, Law, Management; and (5) Engineering and the Built Environment. Humanities had the largest number of participants (32.1%) of the overall sample, whereas the Health Science Faculty had the smallest number of participants with (15.8%) of the overall sample.

Regarding participants degree, the undergraduate degree which was most frequently being completed by the participants (n=28) was the Bachelor of Arts degree (14.73 %), although the postgraduates who participated in the sample were completing many different degree's, hence, the degree which was most frequented by the participants (n=5) was the Master of Business Administration with only 2.6%. In total there were 72 different degrees that the sample were completing, thus, these data shows that there is variation between students' degree in the university. Moreover, 49.4% of participants were postgraduates, and thus, had previously obtained a degree, whereas 50,6% of participants were still completing their undergraduate degree.

The total sample consisted of 190 participants, 173 (90.5%) participants stated that they could speak more than one language, whilst 17 (9.5%) could not. From table 1 one can deduce that a total of 17 monolinguals participated in the study. A monolingual can be defined as an individual who can speak one language (Cenoz,2013). Of those individuals who could not speak more than one language (monolingual sample) majority were females (n=14), and the rest were males (n=3).

Moreover, there were 93 bilinguals who participated, and lastly 80 multilinguals participated in the study. A multilingual is defined as an individual who can speak two or more languages, whereas bilinguals can only speak two languages (Cenoz, 2013). Notably,

multilingual, and bilingual participants in the sample outweigh monolinguals. This is not surprising given how pronounced linguistic diversity is in South Africa (Bangeni, & Kapp, 2007). However, it should be noted that bilinguals, outweighed the multilinguals in the sample.

The researcher identified 37 languages that were spoken by participants throughout the sample, including the 11 official languages of SA (isiXhosa, isiZulu, Afrikaans, English, Sepedi, Sesotho, Setswana, SiSwati, isiNdebele, Xitsonga, and Tshivenda), European languages (Finnish, French, Italian, German, Bulgarian, Portuguese, Spanish, Latin, and Dutch), other African languages (Lingala, Yoruba, South African Sign Language, Swahili, Hausa, Shona, Lingala, Tswana, Urdu, Asante Twi, and Lobedu), and other Indian/Asian languages (Hindi, Gujrati, Japanese, Arabic, and Hebrew) (see Table 2).

The five most spoken languages throughout the sample were English (20.8%), Afrikaans (19.7%), isiZulu (16.2%), isiXhosa (9.8%) and Sotho (6.9%). As stated, all 11 official languages of South Africa were spoken in this multilingual sample, however, there were varying degrees of dominance across all of them (see Table 2).

Table 2

Frequency of Languages Spoken by Participants

Language	1st language (N=190)	2nd Language (N=173)	3rd language (N=80)	4th Language (N=40)	5th language (N=23)
	n(%)	n(%)	n(%)	n(%)	n(%)
Xhosa	9 (5.2)	13 (9.8)	6 (7.5)	3 (7.5)	3 (13.0)
Zulu	28 (16.2)	26 (19.5)	13 (16.3)	7 (17.5)	1 (4.3)
Afrikaans	34 (19.7)	29 (21.8)	10 (12.5)	3 (7.5)	3 (13.0)
English	36 (20.8)	14 (10.5)	6 (7.5)	3 (7.5)	1 (4.3)
Spedi	10 (5.8)	6 (4.5)	3 (3.8)	2 (5.0)	1 (4.3)
Setswana	5 (2.9)	7 (5.3)	4 (5.0)	5 (12.5)	2 (8.7)
Sotho	12 (6.9)	9 (6.8)	14 (17.5)	10 (25.0)	4 (17.4)
Finnish					1 (4.3)
French	4 (2.3)	5 (3.8)	4 (5.0)	1 (2.5)	
Ndebele		4 (3.0)	3 (3.8)	1 (2.5)	
Shona	7 (4.0)	2 (1.5)	2 (2.5)		
Hindi		1 (.8)			1 (4.3)
Lingala			1 (1.3)		
Italitan	1 (.6)	1 (.8)			
Tswana	3 (1.7)	2 (1.5)	2 (2.5)	1 (2.5)	1 (4.3)
Tshivenda	3 (1.7)	4 (3.0)	1 (1.3)		1 (4.3)
Tshixonga			2 (2.5)	1 (2.5)	1 (4.3)
Yorba	2 (1.2)			1 (2.5)	

Table 2 *Continued*

Language	1st language (N=190)	2nd Language (N=173)	3rd language (N=80)	4th Language (N=40)	5th language (N=23)
	n(%)	n(%)	n(%)	n(%)	n(%)
Siswati	2 (1.2)	1 (.8)	3 (3.8)		
Xitsonga	4 (2.3)				
German	1 (.6)	4 (3.0)	2 (2.5)		
SASL	1 (.6)	1 (.8)	2 (2.5)		
sePedi		1 (.8)			1 (4.3)
Bulgarian	1 (.6)				
Portuguese	1 (.6)		1 (1.3)		
Urdu	1 (.6)				
Gujrati					1 (4.3)
Spanish	1 (.6)			1 (2.5)	
Swahili	1 (.6)			1 (2.5)	
Hebrew	3 (1.7)				
Hausa		1 (.8)			
Arabic	1 (.6)		1 (1.3)		
Latin					1 (4.3)
Astante Twi	1 (.6)				
Dutch		2 (1.5)			
Lobedu					
Japanese	1 (.6)				

Note. As the number of languages increase the number of individuals able to speak the number of languages decreases. Hence (n=) decreases with each language group.

3.2 Performance on the MAI

The Metacognitive Awareness Inventory (MAI) examines participants metacognitive awareness, this instrument consists of two subscales, knowledge of cognition and regulation of cognition (Schraw & Dennison, 1994). Under the subcategory of knowledge of cognition, the highest possible score is 85, with a highest score of 40 declarative knowledge, 20 for procedural knowledge, and 25 for conditional knowledge. Whereas the regulation of cognition subcategory has a highest possible score of 175 and is subdivided into planning with a highest score of 35, information strategies with a highest score of 50, comprehension monitoring with a highest score of 35, debugging strategies with a highest score of 25, and evaluation with a highest score of 30. Aim two, which was to describe the participants performance on the Metacognitive Awareness Inventory (MAI) questionnaire regarding the categories of

regulation of cognition and knowledge of cognition, was investigated by using descriptive statistics and Pearson correlations, the results are summarised in Table 3, and 4. Scoring norms have shown that for the MAI total score 144.47 is the norm, 206. 85 is considered high and 102.37 is considered low (Schraw & Dennison, 1994; Young & Fry, 2008). Regulation of cognition scores show that 67.45 is the norm, 138.16 is high and 48.24 is low (Schraw & Dennison, 1994; Young & Fry, 2008). Knowledge of cognition scores show that 77.02 is the norm, 58.34 is low and 82.43 is high (Schraw & Dennison, 1994; Young & Fry, 2008).

Results from descriptive statistics and frequencies run on the *MAI total score* revealed that the participants mean score was 189.19 and the standard deviation was 21.11. The mean score suggests participants *MAI total score* is high, thus relating to an overall higher metacognitive awareness. However, the mean score (189.19) is substantially above average than what is indicated as the midpoint/average (144.47) in Schraw and Dennison's (1994) MAI development. However, in comparison to Young and Fry (2008), the data suggests that the students *MAI total score* mean was relatively normative in the given student population (206.85), as a result of external comparison. Moreover, the SD (21.11) suggests that this data has a high standard deviation which indicates that the data is widely distributed (Field, 2013). Furthermore, the Cronbach alpha value (.876) indicates that the items in the MAI are closely related and have internal consistency. The Cronbach alpha is an internal consistency measure that statistically measures and shows how closely related various items in a scale are (Field, 2013).

The subcategory *knowledge of cognition*'s mean was 62.36 and the standard deviation was 8.12 with a Cronbach alpha of .738. The mean score suggests participants *knowledge of cognition*'s mean (62.36) is moderate, as higher scores relate to a higher metacognitive awareness (Schraw & Dennison, 1994). Thus, relating to a reasonable *knowledge of cognition*. However, the mean score obtained by participants (62.36) is below average than what is indicated to be the midpoint/average (77.02) in Schraw and Dennison's (1994) *knowledge of cognition.* Moreover, in Young and Fry's (2008) study the mean score for the *knowledge of cognition* subcategory was 68.69 with a SD of 7.28, as a result of external comparison. Furthermore, the SD of the sample in this study (8.12) suggests that this data has a relatively high standard deviation which indicates that the data is moderately distributed (Field, 2013). The Cronbach alpha value (.738) indicates that the items in the knowledge of cognition subcategory are closely related and have internal consistency.

The subcategory *regulation of cognition* mean score was 126.82 and the standard deviation was 14.50 with a Cronbach alpha of .830. The mean score suggests participants *regulation of cognition*'s mean (126.82) is substantially higher, thus relating to a higher *regulation of cognition*. Hence, the mean score (126.82) is greatly above average than what is indicated to be the midpoint/average (67.45) in Schraw and Dennison's (1994) *regulation of cognition.* Moreover, the SD (14.50) suggests that this data has a high standard deviation which indicates that the data is widely distributed (Field, 2013). However, in Young and Fry's (2008) study the mean score for the *regulation of cognition* subcategory was 138.16 with a SD of 14.94, as a result of external comparison. Furthermore, the Cronbach alpha value (.830) indicates that the items in the *regulation of cognition* subcategory are closely related and have internal consistency.

Table 3

Descriptive Statistics on the MAI, Knowledge of Cognition, and Regulation of Cognition

Variable	Participants (n=190)				
	M	SD	Min	Max	Median
MAI Total	189.19	21.11	134.00	246.00	189.5
Knowledge of Cognition	62.36	8.12	40.00	82.00	63.0
Declarative Knowledge	29.16	4.62	15.00	39.00	30.00
Procedural Knowledge	14.64	2.28	9.00	20.00	15.00
Conditional Knowledge	18.55	2.63	10.00	25.00	19.00
Regulation of Cognition	126.82	14.50	86.0	169.0	127.0
Planning	24.02	4.09	13.00	35.00	24.00
Comprehension Monitoring	25.50	3.72	13.00	35.00	25.50
Information Management	37.44	4.69	24.00	48.00	38.00
Debugging Strategies	19.67	2.52	13.00	25.00	20.00
Evaluation	20.17	3.41	11.00	30.00	20.00

Note. The theoretical minimum and maximum for The MAI total score is 52 and 260. Knowledge of cognition has a minimum of 17 and a maximum of 85. Declarative Knowledge has a minimum of 8 and maximum of 40. Procedural Knowledge has a minimum of 4 and maximum of 20. Conditional Knowledge has a minimum of 5 and maximum of 25. Regulation of cognition has a minimum of 35 and a maximum of 175. Planning has a minimum of 7 and maximum of 35. Information Management Strategies has a minimum of 10 maximum of 50.

Comprehension Monitoring has a minimum of 7 maximum of 35. Debugging Strategies has a minimum of 5 maximum of 25. Evaluation has a minimum of 6 maximum of 30.

Table 3 depicts the differences in the means on declarative knowledge (M =29.16, SD =4.62), procedural knowledge (M = 14.64, SD = 2.28), conditional knowledge (M = 18.55, SD = 2.63), planning (M = 24.02, SD = 4.09), information management strategies (M = 37.44, SD = 4.69) comprehension monitoring (M = 25.50, SD = 3.72), debugging strategies (M = 19.67, SD = 2.52), and evaluation (M = 20.17, SD = 3.41). From these data it is apparent that participants scored substantially higher on information management strategies. Whereas scores for declarative knowledge, comprehension monitoring, and planning were considerably high; participants score for evaluation, debugging strategies, and conditional knowledge were lower. However, scores for procedural knowledge were substantially low in comparison to scores on information management strategies.

A higher score on MAI and subscales of regulation of cognition and knowledge of cognition equates to being more a more metacognitively aware student. In total 12.6% of the participants obtained a score of 32/40 on the item of declarative knowledge; 21.6% obtained a score of 14/20 on the item of procedural knowledge; 18.4% obtained a score of 17/25 on the item of conditional knowledge; 10.5% obtained a score of 24/35 on planning; 12.1% obtained a score of 25/35 on the item of comprehension monitoring; 14.2% obtained a score of 39/50 for information management strategies; 13.2% obtained a score of 21/25 for debugging strategies; and 13.2% obtained a score of 21/30 for the evaluation item.

Table 4

Pearson correlations between the subcategories of the MAI and MAI Total Score.

Variable	DK	PK	CK	P	CM	IM	DS	E
Procedural Knowledge	.507**	–						
Conditional Knowledge	.523**	.591**	–					
Planning	.531**	.431**	.492**	–				
Comprehension Monitoring	.448**	.468**	.531**	.482**	–			
Information Management	.425**	.506**	.482**	.449**	.502**	–		
Debugging Strategies	.378**	.514**	.490**	.467**	.468**	.494**	–	
Evaluation	.377**	.388**	.428**	.484**	.573**	.500**	.448**	–
MAI Total Score	.756**	.729**	.749**	.766**	.744**	.785**	.700**	.735**

Note. **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). DK= Declarative Knowledge, PK= Procedural Knowledge, CK= Conditional Knowledge, P= Planning, CM= Comprehension Monitoring, IM= Information Management, DS= Debugging Strategies, E= Evaluation.

3.3 Characteristics of Daily Failures of Working Memory

Aim three was to describe the characteristics of daily failures of working memory in terms of the participants' reports on the subcategories of the Working Memory Questionnaire (WMQ), which was investigated by using descriptive statistics, and the results are summarised in Table 5 and 6. The WMQ examines participants daily failures in working memory, this instrument contains three subscales, which are short-term storage, attention, and executive characteristics of working memory (Vallat-Azouvi et al., 2012). In each three domains sub-scores were generated, producing a possible highest score of 40 for each participant, as well as the possible total score 120 (Vallat-Azouvi et al., 2012). Hence, higher scores on the questionnaire indicate more apparent daily failures of working memory, and thus more complaints by the participants.

Table 5

Descriptive Statistics for the WMQ Total Score and Subdomains.

Variable	Mean	Median	Minimum	Maximum	Std. Deviation
Storage Domain	16.12	14.00	0.00	43.00	9.71
Attention Domain	19.74	19.00	3.00	50.00	9.28
Executive Domain	17.56	17.00	1.00	46.00	9.13
Working Memory Total	53.43	50.00	10.00	139.00	25.38

Note. From these values as well as Shapiro-Wilks test of normality (P>0.05) for the WMQ and each domain, it can be concluded that the WMQ and its domains have normally distributed data.

It was observed in the dataset that lower and higher scores on each subscale domain had substantially less frequencies, in comparison to scores the middle of each of the subscales which contained considerably higher frequencies (see Table 5). In total 7.4% participants obtained a score of 18/50 on the executive domain; 5.3% obtained a score of 18/50 and 20/50

on the attention domain; 6.8% obtained a score of 11/50 on the storage domain; 3.7% of participants obtained a score of 44/150, 58/150 and 75/150 on the WMQ (see Table 5).

Furthermore, the storage domain mean (M=16.12, SD=9.71) was the lowest, the executive domain had the second highest mean (M=17.56, SD= 9.13), and the attention domain had the highest mean (19.74, SD= 9.28). The storage domain relates to short-term storage and refers to the ability to store information for a short period of time. The mean on the storage domain having the lowest score (M=16.12, SD=9.71) and 6.8% of participants obtained a score of 11/50 on the storage domain, this indicates that this domain had the least number of complaints by participants, and thus, participants experience the least amount daily failures in this domain.

The executive domain had the second highest mean (M=17.56, SD= 9.13) and 7.4% participants obtained a score of 18/50. Thus, participants in the sample may be experiencing a moderate to high number of daily failures in this domain, as the working memory domain refers to aspects such as planning, and making decisions, and shifting between strategies. Therefore, participants may be experiencing daily issues in these areas. The attention domain had the highest mean (19.74, SD= 9.28) with 5.3% of participants obtaining a score of 18/50 and 20/50. This score indicates that participants in the sample are experiencing the highest number of failures in this domain, and thus their attention may be affecting their concentration, due to mental fatigue, dual-task processing, or distractibility.

Table 6

Pearson Correlations for the WMQ Total Score and Subdomains

Variable	Attention Domain	Executive Domain	WMQ Total Score
Executive Domain	.744**	–	
WMQ Total Score	.921**	.888**	–
Storage Domain	.753**	.668**	.899**

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

Cronbach alpha of the WMQ was .886 therefore, the instrument demonstrates internal consistency. Moreover, when analysing the internal consistency of the WMQ and the domains, it was concluded based on Pearson's correlation (2-tailed) that executive domain (.888 p<.001),

attention domain (.921 p<.001), storage domain (.899 p<.001). Therefore, based on the values obtained on the Sig. (2-tailed) it was concluded that the WMQ is a valid measure and more importantly, displays criterion validity (see Table 6).

3.4 Relationship between WM, Metacognition, and Academic Achievement

Aim four, which was to explore the correlation between academic achievement in university students and the subcategories of metacognition as measured by the MAI, was investigated by using Pearson correlational analysis and the results are summarised in Table 8. The correlations between academic achievement in university students and the domains of daily failures of WM as measured by WMQ summarised in Table 8, as well as the MAI and domains of daily failures of WM as measured by the WMQ were explored using Pearson correlations and are summarised in table 9.

Table 7

Academic Achievement Sample Characteristics

Statistics	Academic Achievement
Mean	75.25
Median	75.33
Standard Deviation	9.40
Minimum	52.67
Maximum	96.33

Table 7 describes the academic achievement characteristics for the sample. The mean of the sample was 75.25 and the standard deviation was 9.40. Furthermore, the minimum was 52.67 and the maximum was 96.33. This indicates that the sample's academic achievement in terms of their last three marks obtained (in percentages) is relatively high, given that 75% is considered a distinction (CHE, 2013). Thus, the students in the sample are above average (Du Toit, 2017). Furthermore, the SD indicates that the distribution from the mean is relatively spread out, therefore indicating that students last three percentages aren't widely spread from the mean (75.25). Moreover, there is difference in terms of academic achievement between the minimum and maximum (52.67; 96.33). However, in this study these values do not reflect the degree that was being completed or what year of study the participant was completing. Hence,

Masters level course work is more intensive and difficult than first year, and a MBBCh has more challenging modules than BA modules.

A Pearson correlational analysis was run between WMQ and MAI academic achievement and the MAI, academic achievement and the WMQ. A preliminary check was carried out to make sure that the assumptions of normality, linearity, significant outliers and approximately normally distributed data were met (Field, 2013). Furthermore, weak correlation is smaller than 0.3 to 0.3, a moderate correlation is 0.3 to 0.5, a strong correlation is 0.5 to 0.7, and a very strong correlation is 0.7 to 1.00 (Field, 2013).

The Pearson correlation demonstrated that daily failures in working memory (WMQ) did not significantly correlate with academic achievement, however a large effect size was present ($r = .021$, $n = 190$, $p = >.005$, $\eta^2p = .994$). Metacognition (MAI) did not correlate with academic achievement however a large effect size was present ($r = .075$, $n = 190$, $p = >.001$, $\eta^2p = .993$). Working memory (WMQ) had a negative but weak correlation to metacognition (MAI) and was statistically significant with a large effect size ($r = -.288$, $n = 190$, $p = <.001$, $\eta^2p = 983$). Partial eta squared calculated, and results show that a large effect size was present between metacognition (MAI) and academic achievement; a large effect size was present between working memory (WMQ) and metacognition; and lastly, a large effect size was present between working memory (WMQ) and academic achievement.

Table 8

Pearson Correlation between MAI Total Score, WMQ Total Score, and Academic Achievement

Variable	MAI Total Score	WMQ Total Score
2. WMQ Total Score	-.288**	–
3. Academic Achievement	0.075	0.021

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

This negative statistically significant correlation between working memory (WMQ) and metacognition (MAI) ($r= -0.288$, $p=<.01$) (see Table 8) indicates when the scores on the MAI increase, the scores on the WMQ decrease. This would indicate that better metacognition is associated with fewer failures of working memory. Furthermore, a Pearson correlational analysis was run on subscales of both instruments in order to determine their relationship, majority of the items were significantly correlated, except for conditional knowledge and executive domain, comprehension monitoring and storage domain, comprehension monitoring

and attention domain, comprehension monitoring and executive domain, information management strategies and attention domain, evaluation and storage domain, evaluation and executive domain, and evaluation and attention domain.

Moreover, the correlation between academic achievement and metacognition (MAI) resulted in a non- significant correlation, (r=0.075, p=>0.05), which demonstrates that there is no relationship between two variables. Lastly, the correlation between working memory (WMQ) and academic achievement demonstrates a non-significant relationship (r=0.021, p=>0.05) (see Table 8). This suggests that there is no relationship between the two variables. Hence, as academic achievement moves in one direction, daily failures of WM move in another.

The Pearson correlations run on the subcategories of the MAI as measured by the MAI and the domains of the WMQ as measured by the WMQ resulted in numerous significant correlations (see Table 9). However, the subcategories and domains which were non-significant were the following, conditional knowledge and executive domain (r= -0.136, p=>0.05), storage domain and comprehension monitoring (r= -0.093, p=>0.05), attention domain and comprehension monitoring (r= -0.119, p=>0.05), executive domain and comprehension monitoring (r= -0.013, p=>0.05). Therefore, these subcategories, domains and total scores mentioned above have no relationship between them.

Moreover, the WMQ total score and comprehension monitoring (r= -0.116, p=>0.05), attention domain and information management (r= -0.127, p=>0.05), evaluation and storage domain (r= -0.100, p=>0.05), evaluation and attention domain (r= -0.062, p=>0.05), evaluation and executive domain (r= -0.016, p=>0.05), evaluation and WMQ (r= -0.085, p=>0.05), and executive domain and MAI (r= -.207, p=>.0.05). Therefore, these subcategories, domains and total scores mentioned above have no relationship between them.

Table 9

Correlations Between Subcategories and Domains of the MAI and WMQ.

Variable	Declarative Knowledge	Procedural Knowledge	Conditional Knowledge	Planning	Comprehension Monitoring	Information Management	Debugging Strategies	Evaluation	Storage Domain	Attention Domain	Executive Domain	MAI Total Score
Procedural Knowledge	.507**	–										
Conditional Knowledge	.523**	.591**	–									
Planning	.531**	.431**	.492**	–								
Comprehension Monitoring	.448**	.468**	.531**	.482**	–							
Information Management	.425**	.506**	.482**	.449**	.502**	–						
Debugging Strategies	.378**	.514**	.490**	.467**	.468**	.494**	–					
Evaluation	.377**	.388**	.428**	.484**	.573**	.500**	.448**	–				
Storage Domain	-.304**	-.260**	-.226**	-.202**	-0.093	-.162*	-.245**	-0.100	–			
Attention Domain	-.298**	-.277**	-.264**	-.240**	-0.119	-0,127	-.183*	-0,062	.726**	–		
Executive Domain	-.229**	-.236**	-0.136	-.263**	-0.013	-.147*	-.166*	-0,016	.636**	.717**	–	
MAI Total Score	.756**	.729**	.749**	.766**	.744**	.785**	.700**	.735**	-.297**	-.274**	-.207	–
WMQ Total Score	-.334**	-.292**	-.218**	-.259**	-.116	-.191**	-.246**	-.085	.899**	.921**	.888**	.288**

Note. **Correlation is significant at 0.01 level (2-tailed). *Correlation is significant at 0.05 level (2-tailed). The table describes the correlations between the subcategories on the MAI and the domains on the WMQ, to determine whether there was a relationship between the two variables.

Chapter Summary

Regarding Demographics, the total sample consisted of participants (N=190). The majority of the participants were between the ages of 18 and 25 years (n=116). Majority of participants identified as female (64.8%), and data suggest that Masters students were most willing to complete the study (25.8%). Humanities had the largest number of participants (32.1%) of the overall sample, Moreover, 49.4% of participants were postgraduates, and thus, had previously obtained a degree, whereas 50,6% of participants were still completing their undergraduate degree. Lastly, 173 (90.5%) participants stated that they could speak more than one language, whilst 17 (9.5%) could not. From table 1 one can deduce that a total of 17 monolinguals participated in the study.

Participants mean score on the MAI was 189.19 and the standard deviation was 21.11. The mean score suggests participants *MAI total score* is high, thus relating to an overall higher metacognitive awareness. The subcategory *knowledge of cognition*'s mean was 62.36 and the standard deviation was 8.12. The mean score suggests participants *knowledge of cognition*'s mean (62.36) is moderate. Thus, relating to a reasonable *knowledge of cognition*. However, the mean score obtained by participants (62.36) is below average than what is indicated to be the midpoint/average (77.02) in Schraw and Dennison's (1994) *knowledge of cognition.* The subcategory *regulation of cognition* mean score was 126.82 and the standard deviation was 14.50. The mean score suggests participants *regulation of cognition*'s mean (126.82) is substantially higher, thus relating to a higher *regulation of cognition*. Hence, the mean score (126.82) is greatly above average than what is indicated to be the midpoint/average (67.45) in Schraw and Dennison's (1994) *regulation of cognition.*

The storage domain mean (M=16.12, SD=9.71) was the lowest, the executive domain had the second highest mean (M=17.56, SD= 9.13), and the attention domain had the highest mean (19.74, SD= 9.28). The storage domain relates to short-term storage and refers to the ability to store information for a short period of time. The mean on the storage domain having the lowest score (M=16.12, SD=9.71) and 6.8% of participants obtained a score of 11/50 on the storage domain, this indicates that this domain had the least number of complaints by participants, and thus, participants experience the least amount daily failures in this domain.

Regarding academic achievement, the mean of the sample was 75.25 and the standard deviation was 9.40. Furthermore, the minimum was 52.67 and the maximum was 96.33. This indicates that the sample's academic achievement in terms of their last three marks obtained

(in percentages) is relatively high, given that 75% is considered a distinction (CHE, 2013). The Pearson correlation demonstrated that daily failures in working memory (WMQ) did not significantly correlate with academic achievement, however a large effect size was present ($r = .021$, $n = 190$, $p = >.005$, $\eta^2p = .994$). Metacognition (MAI) did not correlate with academic achievement however a large effect size was present ($r = .075$, $n = 190$, $p = >.001$, $\eta^2p = .993$). Working memory (WMQ) had a negative but weak correlation to metacognition (MAI) and was statistically significant with a large effect size ($r = -.288$, $n = 190$, $p = <.001$, $\eta^2p = .983$).

4.1 Chapter Four: Discussion

The purpose of this study was to investigate the associations between metacognitive capacity and daily failures of WM in university's students' academic achievement. This chapter will present a discussion of the key findings under the light of the available literature. The structure of this section is guided by the aims.

Demographic characteristics of the sample

The first aim was to describe the demographic characteristics of the sample. The total sample consisted of 190 participants, 173 participants (90.5%) could speak another language, whilst 17 (9.5%) could not (M = 2.59, SD = 1.30, p<,001). Given the linguistic diversity in South Africa, it was not surprising that 90.5% of the sample was bi/multilingual (Kamwangamalu, 2012). It was observed in the database that of those individuals who could not speak more than one language (monolingual sample) majority were females (n=14), and males (n=3). Given that proficiency was not evaluated, participants answered this questions based on their personal assessment of proficiency and language experience.

The participants reported a wide variety of languages, which include the 11 official languages of South Africa, plus several other languages from other countries. This is not surprising given how pronounced linguistic diversity is in South Africa (Bangeni, & Kapp, 2007). Furthermore, learners in South Africa are exposed to various languages, as they are required to be formally trained in at least two languages in order to pass their Matric examinations (Department of Education, 1997). Therefore, this may also contribute to the reason why 177 participants in this study could speak more than one language.

Furthermore, the total sample of participants (N=190) was divided into six age groups and consisted of the following, 18-25 (62%), 26-33 (17%), 34-41 (11%), 42-49 (5%), and 50-57 (5%). The age group of 18-25 was most prevalent in the study. This may be because these ages are more prevalent in the university among full time registered students, as they have fewer responsibilities due to their age (i.e., children or jobs) (Arnett, 2007).

Six categories for gender self- identification were provided as an option, of which the most selected females 64.8% (n=130). According to Jackson et al. (2001) women are more likely than men to engage in online activities that involve exchanging information and communication. Whereas males are likely to engage in online activities that seek out information (Jackson et al., 2001; Smith, 2008). According to the Statistics on Post-School Education and Training in South Africa, in 2016 & 2017, higher education institutions now

compromise of 40.6% males and 59.3% females (DHET, 2020), this may also explain the high response rate of females in the study.

Moreover, the level of study was separated into 1st year (15.3%), 2nd year (20%), 3rd year (15.3%), Honours (17.4%), Masters (25.8%), and Ph.D. (6.3%). These data suggest that Masters students were most willing to participate. Over 1.7 million people in South Africa have degrees, which is about 6% of the country's population (Department of Higher Education and Training, 2022). These include Masters, Bachelor's, Postgraduate Diplomas, and Honours degrees (Department of Higher Education and Training, 2022). The country's 26 public universities reportedly have about a million students each year (Department of Higher Education and Training, 2022).

A 49.4% of participants were postgraduates, and thus, had previously obtained a degree, whereas 50,6% of participants were still completing their undergraduate degree, with the BA degree being the most frequent degree being completed. The majority of the participants were completing an undergraduate Bachelor of Arts degree. Through participating in research studies, students completing a BA (Bachelor of Arts) may gain hands-on experience and a deeper understanding of various fields of interest.

Participants' performance on the Metacognitive Awareness Inventory (MAI)

The second aim that will be discussed is the participants' performance on the Metacognitive Awareness Inventory (MAI). The Metacognitive Awareness Inventory (MAI) consists of two subscales, knowledge of cognition and regulation of cognition. Knowledge of cognition subscale contains declarative knowledge, procedural knowledge, and conditional knowledge. Whereas, the regulation of cognition subscale contains planning, information strategies, comprehension monitoring, debugging strategies, and evaluation.

The current distribution data for the MAI in this study is comparable to that reported by Young and Fry (2008) who reported higher mean (206.85) and SD (20.99) for their sample in comparison to that of this study (M= 189.19, SD= 21.11). Therefore, one could interpret this as higher levels of the construct of the MAI total score, which indicates that this study was above average in comparison to norms (Schraw & Dennison, 1997). Thus, wits students' metacognitive awareness was just above the average university student. Moreover, the current distribution data is below to that reported by Young and Fry (2008), who reported similar mean (68.69) and SD (7.28) for their sample in comparison to that of this study (M= 62.36, SD=

8.12) Therefore, one could interpret this as below average for the subcategory of knowledge of cognition, which indicates that this study was just below average. Thus, wits students' knowledge of cognition was above the average university student. Furthermore, the current distribution data is comparable to that reported by Young and Fry (2008), who reported similar mean (138.16) and SD (14.94) for their sample in comparison to that of this study (M= 126.82, SD= 14.50) Therefore, one could interpret this as above average for the subcategory of regulation of cognition. Thus, wits students' regulation of cognition was above the average university student.

According to Schraw and Dennison (1994) a higher score in both subcategories, as well as on the individual subcategories correlates to a heightened metacognitive awareness in the individuals. One of the key findings in this aim was that students who participated in this study scored substantially higher on information management strategies. Whereas scores for declarative knowledge, comprehension monitoring, and planning were moderate, and participants score for evaluation, debugging strategies, and conditional knowledge were considered low by comparison. Moreover, scores for procedural knowledge were substantially low in contrast to scores on information management strategies.

Prevalence and characteristics of daily failures of working memory

The third aim that will be discussed is the prevalence and characteristics of daily failures of working memory in terms of the participants' reports on the short-term storage, attention, and executive dimensions of the WMQ. The Working Memory Questionnaire (WMQ) examines participants daily failures in working memory, this instrument contains three subscales, which are short-term storage, attention, and executive characteristics of working memory (Vallat-Azouvi et al., 2012).

Furthermore, students with daily failures in working memory may take considerably longer to memorise new information that is presented to them at school or at university (Freeman et al., 2017; Tariq & Noor, 2012; Vallat-Azouvi et al., 2012). Hence, students may quit the activity out of annoyance and disappointment in themselves (Tariq & Noor, 2012). Furthermore, Abu-Rabia (2003), stated that significant correlations occurred between the working memory and academic achievement. The findings in the study (Abu-Rabia, 2003), were consistent with the findings of Swanson and Berninger (1996), as significant correlations were found in their study between working memory and reading, as well as between working

memory and writing ability; hence, significant correlations were found between working memory and academic achievement.

The Working Memory Questionnaire (WMQ) mean was 53.43, the standard deviation was 25.38. The storage domain mean (M=16.12, SD=9.71) was the lowest, the executive domain had the second highest mean (M=17.56, SD= 9.13), and the attention domain had the highest mean (19.74, SD= 9.28). The The mean on the storage domain having the lowest score (M=16.12, SD=9.71) indicates that this domain had the least number of complaints by participants, and thus, participants experience the lowest number of daily failures in this domain. According to Vallat-Azouvi et al. (2012), "higher scores corresponded to more difficulties/complaints" (p.6).

The above data concerning the means and standard deviations of the WMQ, and its domains can be compared to Guariglia's et al. (2020) normative Italian sample data. In their study they obtained mean and standard deviation values for (both men and women) with between 13-20 yeas of education and broke it down into total WMQ, executive domain, attention domain, and storage domain. The men in the total WMQ (M=30.75, SD=14.73) and in comparison, the women (M=29.36, SD=12.29). In the executive domain, the men (M=10.63, SD=5.8), whereas the women (M=10.29, SD=4.80). Additionally, in the attention domain men (M=10.85, SD=5.39) and women (M=10.62, SD=4.89). Lastly in the storage domain, men (M=9.38, SD= 4.85) and the women scored (M=8.53, SD=5.02) (Guariglia's et al., 2020).

The executive domain had the second highest mean (M=17.56, SD= 9.13), this domain of working memory refers to aspects such as planning, and making decisions, and shifting between strategies. This score indicates that participants may be experiencing problems in their executive domain. The attention domain mean had the highest mean (19.74, SD= 9.28). Therefore, with the attention domain attaining the highest mean (19.74, SD= 9.28), this score indicates that students may be experiencing problems in their attention which is affecting their concentration, due to mental fatigue, dual-task processing, or distractibility. In a study conducted by Kane et al. (2007) it was revealed that individuals with low attentional control and capacity tend to experience mind-wandering whenever they perform or engage in real world tasks which prove to be challenging. Thus, students may be unaware of their failures in working memory when they are distracted and may be inattentive to both primary and secondary task demands (Teasdale et al., 1993). These entail memorising items, and students noticing which items they have remembered (Adam & Vogel, 2017).

Therefore, it can be concluded that the frequency of high scores in the attention domain as well as in the executive domain and storage domain and in this study demonstrates that there are students at the University of the Witwatersrand experiencing daily failures in their working memory, such as being able to recall information, struggling with mental calculations and comprehensions, planning and making decisions, as well as battling with their concentration and mental fatigue. Thus, the results that were found in this study, are supported by findings by Cowan (2001) and McElree (2001), as these researchers suggest that focusing on one's attention is critical to the differences in working memory among individuals. Furthermore, Adam and Vogel (2017) maintain that when subjects' attentional control is fully engaged, individuals tend to reach an optimal level of performance, while when it is not, individuals tend to perform poorly. However, research suggests that the ability to expand one's attentional capacity can increase with practice (Verhaeghen & Basak, 2005; Verhaeghen, Cerella, & Basak, 2004).

Adam and Vogel (2017) conducted a series of WM and metacognitive awareness experiments with the intention of exploring if participants were able to accurately identify their failures. Only 28% of the participants were able to identify their failures due to external factors, such as the presence of external distractions, as well as the increasing number of mind wanderings. The study also placed a strain on the participants' executive resources. Additionally, instead of focusing on their thoughts, the participants reported their perceived performance (Adam & Vogel, 2017). However, in the current study the researcher was not assessing whether participants could successfully identify their daily failures of working memory. Nevertheless, this study conducted by Adam and Vogel (2017) highlights the importance of studying this construct in individuals, as many of them are facing daily failures in their WM, as is evident in the current study.

Correlation between academic achievement in university students and the subcategories of metacognition

The fourth aim that will be discussed is the correlation between academic achievement in university students and the subcategories of metacognition as measured by the MAI. The Metacognitive Awareness Inventory has been used as a tool for assessing the academic achievement of students (Amzil & Stine-Morrow, 2013). Moreover, the correlation between academic achievement and metacognition (MAI) resulted in a non- significant correlation, ($r = .075$, $n = 190$, $p = >.001$, $\eta 2p = .993$), which demonstrates that there is no relationship between

two variables. This contrasts what Coutinho (2007); Costa & Kallick (2001); Pradhan & Das (2021); and Van der Stel & Veenman (2010) found in their research, as they found metacognition to be a strong predictor of academic achievement and learning.

Furthermore, the current study's findings contrast those findings that were found in Young and Fry's (2008) study, as significant correlations were found between the MAI and academic achievement (M=206.85, SD=20.99). Furthermore, knowledge of cognition was positively correlated with students GPA, as well as their end of year marks (r= 0.26, p=<.05). Additionally, regulation of cognition factor was also positively correlated with students GPA, as well as their end of year marks (r= 0.27, p=<.05). Lastly, Swerdzewski and Burchard (2009) study found significant results when analysing the effects of implementing metacognitive learning and regulation into a course that focused on learning theories and applying practical strategies to other modules; this course significantly improved the students' skills. Thus, having the necessary metacognitive skills and knowledge can help students excel in their studies, as they are more aware of their own learning process and can easily adopt the learning styles that are appropriate for them (Pradhan & Das, 2021; Young & Fry, 2008).

Correlations between academic achievement in university students and the domains of daily failures of WM

The fifth aim that will be discussed is the correlations between academic achievement in university students and the domains of daily failures of WM as measured by WMQ. The correlation between working memory (WMQ) and academic achievement demonstrates a non-significant relationship, thus displaying that there is no relationship between the two variables ($r = .021$, $n = 190$, $p = >.005$, $\eta 2p = .994$). (Field, 2013). This contrasts the research published by Alloway & Alloway (2010) and Hassanbeigi et al. (2011). According to Alloway & Alloway (2010), working memory is a strong predictor of academic success. Working memory problems can lead to failures in various tasks at university, such as remembering instructions and keeping track of one's progress in difficult situations (Hassanbeigi et al., 2011).

Furthermore, the current study contrasts the findings in the study by Abu-Rabia (2003) and Swanson and Berninger (1996), as significant correlations were found in their study between the construct of working memory and reading, as well as between working memory and writing ability; hence, the study supported the hypothesis that under certain conditions, the

performance of working memory and academic achievement ((text generation (writing and comprehension)) can improve, as the correlation was positive and significant (p=<.01).

Fougnie et al. (2015) have stated that a few examples of the cognitive processes with strong connections to working memory, are attentional control, problem solving, language, logic, and awareness. Although, in this study, the present obstacles to academic attainment for university students are interlaced with daily failures in working memory (Vallat-Azouvi et al., 2012). Working memory is said to be and act as a bottleneck for learning, this is due to the incremental nature of learning, that is gradually being built over time (Hassanbeigi et al., 2011). Therefore, disruptions such as an inability to retain information, or poor attentional control or capacity, which is a direct result of poor working memory can jeopardize academic achievement (Hassanbeigi et al., 2011). One of the most common reasons why students fail to achieve their academic goals is due to their lack of attention, studying, incomplete assignments, or not being able to properly concentrate in exams or tests (Hassanbeigi et al., 2011).

Correlation between subcategories of metacognition as measured by the MAI and domains of daily failures of WM as measured by the WMQ

The sixth aim that will be discussed is the correlation between subcategories of metacognition as measured by the MAI and domains of daily failures of WM as measured by the WMQ. There is a statistically significant (p=<.01) correlation between working memory (WMQ) and metacognition (MAI) (r=-.288) which demonstrates that when there is a positive change in one variable, there is a negative change in another ($r = -.288$, $n = 190$, $p = <.001$, $\eta 2p = 983$). The study conducted by Aghdar et al. (2020) sought to determine if working memory and metacognition could help mediate the relationship between academic performance and self-regulation. It revealed that there was a direct and significant relationship between working memory and executive functions (p=<.01). There was a significant relationship observed between the variables of metacognition and working memory with academic learning and academic self-regulation (p=<.01) (Aghdar et al., 2020).

Moreover, studies have revealed that the executive functions of individuals can predict the use of metacognitive techniques and promote diversity within academic self-regulatory processes. Furthermore, they also concluded that the relationship between self-regulation learning, WM, and executive functions can be mediated by metacognition, as these factors interact with each other (Follmer & Sperling, 2016; Garner, 2009). This study while it relates

to the research in question, explored the construct of working memory and not daily failures of working memory. It's believed that researchers may have underestimated the occurrence of working memory failures, particularly if failures in working memory are associated with being off track, task-related interference, or digress from one's work as a result of external distractions such as talking, or loud noises (Adam & Vogel, 2017).

Furthermore, the correlational analysis run subcategories of Regulation of Cognition in the Metacognitive Awareness Inventory and the short-term storage, attention and executive domains of the Working Memory Questionnaire revealed that majority of the items were significantly correlated. These results indicate that both metacognition and working memory are dependent on the control mechanisms that participants use to manage their actions in learning and studying (Adam & Vogel, 2017).

Furthermore, procedural knowledge and declarative knowledge were significantly correlated ($r = .507$, $p = <0.01$). Procedural knowledge refers to the use of students' knowledge to complete a process or procedure. It involves understanding how to implement learning methods, such as strategies (Young & Fry, 2008). Whereas declarative knowledge refers to student's acknowledgement of what they are capable of and how they are able to use their skills (Young & Fry, 2008). Given that students at a university level should be able to maximise their abilities by being able to implement learning methods, utilising their skills, as well as the necessary strategies that they have been taught over their school and university career, in order to achieve the desired outcome (Balashov et al., 2021; Urban et al., 2021).

Conditional knowledge refers to having the necessary knowledge about when and how they should use learning procedures, this can be done through simulations (e.g., practicing oral presentations) (Young & Fry, 2008). Declarative knowledge and conditional knowledge were significantly correlated ($r = .523$, $p = <.01$). Due to student's acknowledgement of what they are capable of, this translates into how they should be studying and when they should be studying (Alloway & Alloway, 2010; Balashov et al., 2021; Reisoğlu et al., 2020; Urban et al., 2021). Although, planning refers to setting goals and allocating the necessary resources prior to starting their learning (Young & Fry, 2008). Declarative knowledge and planning were significantly correlated ($r = .531$, $p = <.01$). Due to student's acknowledgement of what they are capable of, this then translates into allocating the necessary resources prior to starting their learning (Young & Fry, 2008).

Comprehension monitoring refers to students assessing their own learning style or their use of strategies for studying and learning (Young & Fry, 2008). Comprehension monitoring and declarative knowledge were significantly correlated (r=.448, p=<.01). Students use of strategies for studying and learning, is due to their acknowledgement of their capabilities in their modules/subjects (Palennari et al., 2018; Young & Fry, 2008). Therefore, those students who know that they are not doing well in a module/subject, know that they need to apply different strategies when studying or learning for the next test/exam (Schraw & Dennison, 1994; Du Toit, 2017).

Information management strategies refers to how students make use of strategies, skills, and sequences which help improve the efficiency of information management. Information management strategies and declarative knowledge were significantly correlated (r=.425, p=<.01). Due to students acknowledging their capabilities (declarative knowledge), this in turn will have an effect on how these students manage their use of strategies and skills, in order to maximise their information management (Çetin, 2017; Schraw & Moshman, 1995; Young & Fry, 2008). Whereas debugging strategies (the way in which students use strategies to correct errors in their comprehension and performance) was significantly correlated with declarative knowledge (r= .378, p=<.01). Thus, if students are aware of their skills, they will know where they are more likely to make errors. Therefore, these students are more likely to use strategies in learning and studying to correct them in their comprehension and performance (Çetin, 2017; Schraw & Moshman, 1995; Young & Fry, 2008).

Evaluation entails an analysis of how effective one's own performance and strategy is after learning, this item was significantly correlated to declarative knowledge (r= .377, p=<.01). Thus, if students are aware of their capabilities and want to improve, this will entail an analysis of their performance (Du Toit, 2017; Schraw & Moshman, 1995; Young & Fry, 2008). Moreover, executive domain is related to planning, and making decisions, and shifting between strategies, this domain was significantly and negatively correlated to declarative knowledge (r= -.229, p=<.01). Therefore, if students are aware of how well they can do at university, or how well they can manage their learning, this will relate to them making decisions, planning and shifting between strategies (Schraw & Moshman, 1995; Young & Fry, 2008; Vallat-Azouvi et al., 2012). However, there is a negative correlation as the WMQ is assessing daily failures in working memory, thus, higher scores correspond to more difficulties. Therefore, as declarative knowledge increases, executive domain of daily failures decreases (Schraw & Dennison, 1994; Vallat-Azouvi et al., 2012).

Attention domain is related to lack of concentration, due to mental fatigue, dual-task processing, or distractibility, this domain was significantly and negatively correlated to declarative knowledge (r= -.289, p=<.01). Therefore, if students are aware of how well they can do at university, or how well they can manage their learning, this will relate to their concentration in a given module/subject (Schraw & Moshman, 1995; Vallat-Azouvi et al., 2012). The negative correlation indicates that as declarative knowledge increases, the attention domain of daily failures decreases (Schraw & Dennison, 1994; Vallat-Azouvi et al., 2012).

Storage domain relates to short-term storage and refers to the ability to store information for a short period of time, this domain was significantly and negatively correlated to declarative knowledge (r= -.304, p=<.01). Therefore, if students are aware of how well they can do at university, or how well they can manage their learning, this will translate to how often they are studying, (i.e., how often they are repeating information in their short-term memory) as well as students who know they are battling remembering certain information will study harder (Du Toit, 2017; Schraw & Moshman, 1995; Tariq & Noor, 2012; Young & Fry, 2008; Vallat-Azouvi et al., 2012). However, as declarative knowledge increases, storage domain of daily failures decreases (Schraw & Dennison, 1994; Vallat-Azouvi et al., 2012).

Procedural knowledge and conditional knowledge were significantly and positively correlated (r=.591, p=<.01). Thus, students having the necessary knowledge about when they should use necessary learning procedures, as well as when they should complete the learning process is vital in their university journey (Schraw & Moshman, 1995; Young & Fry, 2008). Moreover, procedural knowledge and planning were significantly and positively correlated (r=.431, p=<.01). Students' knowledge of when to complete a process or procedure requires planning, as well as allocating the necessary resources prior to completing this process (Schraw & Moshman, 1995; Young & Fry, 2008).

Procedural knowledge was significantly and positively correlated to comprehension monitoring (r=.468, p=<.01), information strategies (r=.506, p=<.01), debugging strategies (r=.514, p=<.01), and evaluation (r=.388, p=<.01). Metacognition is a skill which helps students develop their cognitive tools, which in turn, makes them more successful in their studies and perform better in various academic subjects (Akben, 2020; Coutinho, 2007; Du Toit, 2017; Schraw & Dennison, 1994). Given the many different contexts in which metacognition can improve academic achievement, educational institutions across the world

are looking for ways to expand academic learning by utilising the cognitive abilities of their students to regulate and monitor their progress. (Bembenutty, 2009; Pradhan & Das, 2021).

Moreover, procedural knowledge was significantly and negatively correlated to the storage domain (r=. -.260, p=.01), the attention domain (r=. -.277, p=.01), and the executive domain (r=. -.236, p=.01). The ability to control and monitor the behaviour that influences an individual's WM on tasks can be used to guide strategy implementation and strategy recognition, is said to be regulated by metacognition (Touron et al., 2010). Thus, the literature shows that working memory differences are related to strategic behaviour in individuals. For instance, those who used higher cognitive monitoring techniques and strategies had a higher working memory span (Dunlosky & Kane, 2007; Turley-Ames & Whitfield, 2003).

Conditional knowledge and planning were significantly and positively correlated (r= .492, p=<.01). Students having the necessary knowledge about when and how they should use learning procedures, requires students to allocate the necessary resources prior to starting their learning (Du Toit, 2017; Young & Fry, 2008). Furthermore, conditional knowledge and comprehension monitoring were significantly and positively correlated (r= .531, p=<.01). Hence, having the necessary knowledge about when and how they should use learning procedures requires students to be assessing their own learning style or their use of strategies for studying and learning (Du Toit, 2017; Schraw & Moshman, 1995; Young & Fry, 2008). Conditional knowledge and information management strategies were significantly and positively correlated (r= .482, p=<.01). Thus, having the necessary knowledge of when and why to use strategies, requires the student to know how students make use of certain strategies (Young & Fry, 2008). Hence, the use of metacognitive strategies stimulates a student's thinking and can result in deeper understanding and improved performance, particularly among students who are struggling (Jain et al., 2017).

Conditional knowledge was significantly and positively correlated to both debugging strategies (r= .490, p=<.01), and evaluation (r= .428, p=<.01). Having the necessary knowledge about when and how they should use learning procedures which requires use of strategies, skills, and sequences that can help students improve in their learning and academic achieement (Schraw & Dennison, 1994; Schraw & Moshman, 1995; Young & Fry, 2008). Through interactions with their peers and teachers (Howlett et al., 2021). This process can be facilitated by the learning environment's dynamic setting, which allows them to reflect on and model their

skills and provides them with the opportunity to control and manage their learning (Howlett et al., 2021).

Moreover, conditional knowledge were significantly and negatively correlated to the storage domain (r= -.226, p=<.01), and the attention domain (r= -.264, p=<.01). Thus, as the student conditional knowledge (knows when and why to use strategies) increases, their attention and storage domains decrease. Given that higher scores on the WMQ relates to more complaints or difficulties, this relationship is not surprising. The results from the current study are supported by Touron et al.'s (2009) research, in which they have maintained that actions that help guide one's working memory ability are mediated by metacognitive control and monitoring (i.e., regulation of cognition and knowledge of cognition).

Planning and comprehension monitoring were significantly and positively correlated (r= .482, p=<.01), students use of strategies for studying and learning requires them to allocate the necessary resources prior to starting their studying (Schraw & Dennison, 1994; Schraw & Moshman, 1995). Planning and information management strategies were significantly and positively correlated (r= .449, p=<.01), students use of strategies to improve the efficacy of information management requires them to allocate the resources prior to starting (Schraw & Moshman, 1995; Young & Fry, 2008). Planning and debugging strategies were significantly and positively correlated (r= .467, p=<.01), the use of strategies to correct errors in comprehension and performance requires students to allocate the necessary resources and set goals (Schraw & Dennison, 1994; Schraw & Moshman, 1995).

Moreover, planning and evaluation were significantly and positively correlated (r= .484, p=,.01), the analysis of how efficient one's own performance and strategy is after learning requires students to set achievable goals (Schraw & Moshman, 1995; Young & Fry, 2008). Furthermore, planning was significantly and negatively correlated to the storage domain (r= -.202, p=<.01 the executive (r= -.263, p=<.01), and the attention domain (r= -.240, p=<.01). Thus, as the students planning increases, their executive, attention, and storage domains decrease. Given that higher scores on the WMQ relate to more difficulties, this was not surprising in this study. Furthermore, according to Amichetti et al. (2013) the link between regulation of cognition and working memory is related to the ability to calculate the availability of resources for various tasks.

Comprehension monitoring was significantly and positively correlated to information management strategies (r = .502, p=<.01), debugging strategies (r = .468, p=<.01), and

evaluation (r = .573, p=<.01). Thus, by students assessing their own learning style or their use of strategies for studying, students make use of different strategies, skills, and sequences which help improve the effectiveness of their information management at university (Romainville, 1994; Schraw & Dennison, 1994). Furthermore, by students assessing their own learning style or their use of strategies for studying, they can correct errors in their comprehension and performance (Romainville, 1994; Schraw & Dennison, 1994). Moreover, these items are related due to students assessing or analysing their own learning style or their use of strategies for studying or after learning (Romainville, 1994; Schraw & Dennison, 1994; Young & Fry, 2008). This is supported by Jain et al. (2017) as these researchers maintain that the use of metacognitive strategies stimulates a student's thinking and can result in deeper understanding and improved performance, particularly among students who are struggling.

The long and short-term memory components are regarded as vital in reading comprehension (Hassanbeigi et al., 2011). Such components play a crucial role in the reader's ability to interpret, manipulate, and store information in WM while processing the text (Hassanbeigi et al., 2011). However, in this study, there was no association between comprehension monitoring and the storage domain. This may be because during comprehension monitoring students use strategies to help them evaluate and control their reading comprehension, rather than actively using their short-term memory/storage component of working memory (Amichetti et al., 2013; Hassanbeigi et al., 2011).

Information management strategies were positively correlated with both debugging (r=.494, p=<.01) and evaluation (r=.500, p=<.01). This is expected because, students make use of strategies, skills, and sequences which help improve the efficiency of information management, these can include organising, summarising, and selective focusing (i.e., information management strategies) (Young & Fry, 2008). Through their selective focusing and organising, these students are more likely to improve their search techniques by continuously monitoring their progress (i.e., evaluation) (Catalano, 2017; Frerejean et al., 2018; Ge et al., 2016). Through monitoring their progress and using debugging strategies, these students are likely to improve their academic performance (Bembenutty, 2009; Coutinho, 2007; Du Toit, 2017; Sreena & Ilankumaran, 2018). These results obtained in the current study are supported by research conducted by Jehangir (2020) and Pollard and Courage (2017). These researchers maintain that when performing complex multitasking, it will result in the student's brain being less activated. Although, as the task difficulty increases, the brain's recruitment of additional neural resources is seen. Thus, students recruitment of additional resources and

processes during complex activities is seen by their metacognitive awareness (Bembenutty, 2009; Coutinho, 2007; Du Toit, 2017; Jehangir, 2020; Pollard & Courage, 2017; Sreena & Ilankumaran, 2018).

Information management strategies were negatively correlated with both the storage domain (r= -.162, p=<.01), and the executive domain (r= -.147, p=<.01). This is expected because, as students' information management strategies increase their storage domain and executive domain decreases (Vallat-Azouvi et al., 2012). This is not surprising given that more complaints on the WMQ leads to a higher score (Vallat-Azouvi et al., 2012). The results in the current study are supported by Du Toit, (2017) and Schraw and Dennison (1994). Hence, students make use of shifting between strategies, skills, and sequences which can improve the effectiveness of information management (i.e., organising). Furthermore, students use of strategies and skills, to improve their management of information (i.e., organising), requires students to be able to switch between strategies if one is not working for them. Therefore, this can help them develop effective strategies and become more aware of where to go next when looking for information that is applicable to their studies (Raes, Schellens, De Wever, & Benoit, 2016).

Debugging strategies and evaluation were significantly and positively correlated (r= .448, p=<.01), students use strategies to correct errors in their comprehension and performance, which entails an analysis of their own performance (Schraw & Dennison, 1994; Sperling et al., 2004; Young & Fry, 2008). Debugging strategies were significantly and negatively correlated with the storage domain (r= -.245, p=<.01), the attention domain (r= -.183, p=<.01), and the executive domain (r= -.166, p=<.01). Thus, the ability to control and monitor the behaviour that influences an individual's WM on tasks can be used to guide strategy implementation and strategy recognition, is said to be regulated by metacognition (Touron et al., 2010). Furthermore, the literature shows that working memory differences are related to strategic behaviour in individuals. For instance, those who used higher cognitive monitoring techniques and strategies had a higher working memory span (Dunlosky & Kane, 2007; Turley-Ames & Whitfield, 2003). It is also reported that the actions that help guide one's working memory ability are mediated by metacognitive control and monitoring (Touron et al., 2009). All the above strategies require the student to have metacognitive awareness for their WM to be functioning at an optimal level (Hassanbeigi et al., 2011). After learning, studying, or an assessment, an evaluation of the strategy used, and the individual's performance is carried out. In this study however, the subscale of evaluation did not correlate with any working memory

questionnaire domain. This may be due to the fact that the evaluation subcategory item is more directed towards strategy and performance, rather than attention, storage or executive domains. (e.g., “I ask myself if I have considered all options after I solve a problem”) (Schraw & Dennison, 1994).

The storage domain and executive domain were significantly and positively correlated (r= .636, p=<.01). There has only been one study that investigated metacognition in the spatial memory domain (Schwartz, 2006). In this study, participants were asked to make JOLs (judgments of learning) in response to learning maps. They were then asked to determine the way to another town from one of the maps (Schwartz, 2006). Schwartz (2006), found that the younger adults were more capable of accurately remembering the directions in the episodic task and thus, were more aware of spatial knowledge acquisition. These findings relate to our findings that younger adults’ storage domain is correlated to metacognition subscales, however, this study did not investigate spatial awareness. Moreover, the storage domain and attention domain were significantly and positively correlated (r= .726, p=<.01). According to a study conducted by Adam & Vogel (2017), all the participants were unable to identify their failures in working memory. However, those with the lowest performance were especially burdened with substandard metacognitive awareness. Researchers found that when subjects' attentional control is fully engaged, individuals tend to reach an optimal level of performance, while when it is not, individuals tend to perform poorly (Adam & Vogel, 2017). These results relate to the current study’s findings as the attention domain had the highest mean (M=19.74, SD= 9.28). Hence, the attention domain received the highest number of complaints about daily failures (Vallat-Azouvi et al., 2012). Therefore, the participants who complained about their daily failures in this domain were experiencing attention and concentration problems, which in turn affected their level of performance (Adam & Vogel, 2017). Additionally, researchers noted that online capacity monitoring could be a type of working memory function that can be hindered by the lack of attentional resources (Amichetti et al., 2013).

Moreover, the executive and attention domains were significantly and positively correlated (r= .717, p=<.01). These results relate to findings by Adam & Vogel (2017), these researchers maintain that if an executive failure occurs, then both metacognition and working memory may suffer. However, to date, there are only a few studies on whether people can effectively monitor daily failures of working memory and implement working memory strategies (Schwartz, 2006; Thomas et al., 2012; Touron et al, 2010). Moreover, according to

a study conducted by Sperling & Follmer (2016), executive functions can predict an individual's self-regulation and metacognition.

Implications of the study

The theoretical implication of this study is that it provides insight that a relationship exists between metacognition and daily failures of working memory in university students. Furthermore, it provides evidence that there is a relationship between daily failures in working memory and metacognitive awareness in students in Universities in South Africa. Furthermore, it provides evidence that students there is a relationship between students age, metacognition, and daily failures of working memory. The practical implication of the study is that MAI instrument and its subscales proved to be reliable and valid when assessing metacognition. Furthermore, the WMQ after running the appropriate tests proved to be a reliable and valid instrument when assessing daily failures of working memory.

4.2 Limitations of Study

The present study has some limitations. First, data on the influence of potentially important moderating variables on WM, metacognition, and academic achievement was not explored. Of particular importance was the presence of medical and psychiatric cognitions (e.g., Depression, ADHD) that may influence WM and metacognition. (Arnold et al., 2020). Second, this study did not include questions on whether participants were using medications to help them concentrate at university, such as Concerta, Adderall, or Ritalin. This information would have been helpful when interpreting the MAI data. Third, the researcher could not test whether the subcategories found in the MAI were significantly higher than those found in other seminal research.

Fourth, the researcher did not collect data on social economic status and quality of education, which has an impact on academic achievement, and could perhaps influences an individual's development of metacognition and WM (Leonard et al., 2015; Sirin, 2005). Fifth, questions of whether participants attended a private or public high school in South Africa would have provided further information into the participants transition into university (Joseph, 2009). Hence, this may have provided further understanding of how well they adjusted to their environment at university, and thus, how well they were performing academically.

Sixth, a clear limitation in this study was that all participants attended the University of the Witwatersrand, thus, these results cannot be generalised to other populations or locations outside this specific context.

Lastly, although the self-report questionnaires used in this study have been described as reliable and valid, there are biases in self-report measures that can be reduced by incorporating additional measures of the constructs that provide a more direct observation. Therefore, it may have been beneficial to include an objective observational instrument in the study, in order to obtain a more objective and balanced data set for this study (Chiarovano et al., 2018).

4.3 Directions for Future Research

Future studies assessing working memory failures and metacognition would benefit from including a clinical group that typically presents with deficits in working memory, for example ADHD (Arnold et al., 2020). This will help elucidate how WM failures may be associated with metacognition and academic achievement. Secondly, studies assessing WM failures, metacognition, and academic achievement would benefit from collecting data on whether participants are using medications to help them concentrate or study, such as Concerta, Adderall, or Ritalin. This will provide insight on the effect these medications have on WM failures, metacognition and academic achievement when interpreting the data. Third, future studies should consider measuring and controlling for several extraneous variables that were excluded from this study, such as SES, educational history, and IQ. Fourth, future studies should consider collecting data on quality of education, which has an impact on academic achievement, as well as on the development of metacognition and WM.

Fifth, future studies should consider including both private and public universities in their sample, as well as trying to incorporate students from as many universities as possible, therefore making their study as generalisable as possible. Lastly, future assessing working memory failures, metacognition, and academic achievement would benefit from including a qualitative component to the study to gain qualitative data, (i.e., minimal verbal prompts and body language) (Field, 2013); therefore, collecting a rich data set on the variables.

Furthermore, future research should be exploring the effects that daily failures have on aspects of everyday living, job satisfaction, and well-being as the current literature on the WMQ is limited. Moreover, there is a need for researchers need to develop a deeper understanding of students' behavioural and cognitive characteristics, as this will help universities improve their lecturing techniques, which in turn will increase students' metacognitive awareness. As when performing complex multitasking, it will result in the student's brain being less activated. Although, as the task difficulty increases, the brain's

recruitment of additional neural resources is seen (Jehangir, 2020; Pollard & Courage,2017). Future research should investigate whether training-induced changes in working memory, induce changes in participants daily failures of working memory.

6. Chapter Six: Conclusion

The results of this study indicate that wits students' overall metacognitive awareness was just below the average university student. Although wits students' knowledge of cognition and regulation of cognition was above the average university student. Students who participated in this study scored substantially higher on information management strategies. Whereas scores for declarative knowledge, comprehension monitoring, and planning were moderate, and participants score for evaluation, debugging strategies, and conditional knowledge were considered low by comparison. Due to students' mean scores on information management strategies being substantially high, it can be stated that these students make use of strategies, skills, and sequences can help improve the efficiency of information management. These can include organising, summarising, and selective focusing.

One of the key findings that emerged from the study was the following, participants score for procedural knowledge was substantially low in comparison to scores on information management strategies. Thus, it is concerning that procedural knowledge scores were substantially lower than information management strategies scores, given that the data suggests that students at a university level are battling with the concept of when to apply their knowledge or to use strategies that have worked for them in the past.

Furthermore, the mean on the storage domain having the lowest score indicates that this domain had the least number of complaints by participants, and thus, participants experience the least number of daily failures in this domain. However, the attention domain attained the highest mean, which indicates that students may be experiencing problems in their attention which is affecting their concentration, due to mental fatigue, dual-task processing, or distractibility. Moreover, the frequency of high scores in the attention domain, executive domain, and storage domain in this study demonstrates that there are students at the University of the Witwatersrand experiencing daily failures in their working memory, such as being able to recall information, struggling with mental calculations and comprehensions, planning and making decisions, as well as battling with their concentration and mental fatigue.

Moreover, participants daily failures in working memory and academic achievement are not related. Therefore, there is no relationship between these two variables. Furthermore,

participants metacognitive awareness and academic achievement are not related. Therefore, there is no relationship between these two variables. Lastly, participants' daily failures in working memory may be related to their metacognitive awareness. Specifically, as the student's metacognition improves, it is possible that their experienced daily failures in working memory may decrease. Therefore, it is important that research continues to investigate metacognitive awareness and academic performance, as well as the metacognitive trends that increase with lowered levels daily failures of working memory.

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Appendices

Appendix 1
Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE:	**PROTOCOL NUMBER: MAPSYC-22-06**
PROJECT TITLE:	Metacognition and Daily Failures in Working Memory: A Deeper Understanding of University Students' Academic Achievement.
INVESTIGATOR	Menschy Katya (2388147)
SCHOOL/DEPARTMENT OF INVESTIGATOR	SHCD/Psychology
DATE CONSIDERED	20 June 2022
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	No Risk
EXPIRY DATE	31 December 2024

ISSUE DATE OF CERTIFICATE 11 July 2022 **CHAIRPERSON** (Dr Nkululeko Nkomo)

cc: Dr Aline Ferreira Correia (Supervisor)

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Katya Nadia Menschy
Signature

Date 12 / 07 / 2022

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 2
Email to participants

Hello!

My name is Katya Menschy. I am doing my Master's degree in Psychology, and I would like to invite you to participate in my study. The title if my study is Metacognition and Daily Failures in Working Memory: A Deeper Understanding of University Students' Academic Achievement (ethics clearance number: MAPSYC-22-06). I am investigating how students' capacity to think about their cognitive functions and regulate their attention and memory affect their academic achievement.

If you would like to know more and are wanting to participate, click here and you will be taken to a page with more information about the study and the link to proceed to take the survey, which should take you no longer than 25 minutes to complete. Participation is anonymous and confidential, and you can withdraw at any time. There are no right or wrong answers.

Link: https://www.surveymonkey.com/r/B2TQCWR

Please feel free to contact either myself or my supervisor if you have any questions.

Katya Nadia Menschy: 2388147@students.wits.ac.za

Dr Aline Ferreira Correia: Aline.FerreiraCorreia@wits.ac.za

Appendix 3

Information Sheet

My name is Katya Nadia Menschy, and I am currently completing my master's degree in psychology at the University of Witwatersrand. I am inviting you to participate in the research that I am conducting with my supervisor Dr Aline Ferreira Correia. The title of my project is: Metacognition and Daily Failures in Working Memory: A Deeper Understanding of University Students' Academic Achievement.

My ethics clearance certificate number is: (MAPSYC-22-06).

The purpose of this research study is to examine the relationship between the way university students in South Africa report on their daily failures of working memory (individuals with daily failures of working memory may struggle to memorise information, they may also have difficulties to performing dual tasks), and if this has any effect on their academic achievement. Furthermore, this research will also examine the way university students in South Africa report on their own cognitive processes and metacognition.

This is an anonymous survey. Some demographic information, such as your age range and gender will be collected, however, no identifying information will be asked – such as names, surnames, or identity numbers. Participation is voluntary; if you chose to take part, you may stop participating at any time if you wish to do so. Your rights will be respected during this research process. This research will be conducted on a platform called SurveyMonkey and will require participants to be connected to a Wi-Fi network or to have their mobile data turned on.

There are no foreseeable risks to participating in this study. Only my supervisor and I will be able to see this data, and information that is collected is confidential. The data that is collected will be reported as a group in my research report which will satisfy the requirement of my degree. Informed consent in this research study will be taken as the you, the participant clicking begin or 'go' to start the survey. Participants will not receive any reimbursements for their participation in this research study. If you wish to receive the results from this study, please contact me via email. The final report is expected to be ready in April 2023, and the results will be shared with you via an email.

If you seek more information, you may contact either myself, my supervisor, or the Human Research Ethics Committee (HREC Non-Medical) telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Katya Nadia Menschy: 2388147@students.wits.ac.za

Dr Aline Ferreira-Correia: Aline.FerreiraCorreia@wits.ac.za

Appendix 4

Self-developed Demographic Questionnaire

Instructions:

Please answer the following questions, there are no right or wrong answers.

Question:
1. What is your age? o 18-25 o 26-33 o 34-41 o 42-49 o 50-57 o 58- and above
2. To which gender identity do you most identify? o Female o Male o Non-binary o Transgender o Gender neutral o None of the above
3. What year of study are you currently completing? o 1st year o 2nd year o 3rd year o Honours o Masters o Ph.D
4. What is the degree you are currently completing? o Degree: o Faculty:
5. Are you satisfied with academic performance? o True o False
6. Please list the three highest marks that you obtained in 2021. o __% o __% o __%
7. Can you speak another language? If yes, what language(s)? o

Appendix 5

Participant Information Sheet

Metacognitive and Working Memory Questionnaire

Welcome to the Metacognition, Working Memory and Academic Achievement Survey!

My name is Katya Nadia Menschy, and I am currently completing my Master's degree in psychology at the University of Witwatersrand. I am inviting you to participate in the research that I am conducting with my supervisor Dr Aline Ferreira Correia. The title of my project is: Metacognition and Daily Failures in Working Memory: A Deeper Understanding of University Students' Academic Achievement.

My ethics clearance certificate number is: (MAPSYC-22-06).

The purpose of this research study is to examine the relationship between the way university students in South Africa report on their daily failures of working memory (individuals with daily failures of working memory may struggle to memorise information, they may also have difficulties to performing dual tasks), and if this has any effect on their academic achievement. Furthermore, this research will also examine the way university students in South Africa report on their own cognitive processes and metacognition.

This is an anonymous survey. Some demographic information, such as your age range and gender will be collected, however, no identifying information will be asked – such as names, surnames, or identity numbers. Participation is voluntary; if you chose to take part, you may stop participating at any time if you wish to do so. Your rights will be respected during this research process. This research will require participants to be connected to a Wi-Fi network or to have their mobile data turned on.

There are no foreseeable risks to participating in this study. Only my supervisor and I will be able to see this data, and information that is collected is confidential. The data that is collected will be reported as a group in my research report which will satisfy the requirement of my degree. Informed consent in this research study will be taken as the you, the participant clicking 'ok' and then next to start the survey. Participants will not receive any reimbursements for their participation in this research study. If you wish to receive the results from this study, please contact me via email. The final report is expected to be ready in April 2023, and the results will be shared with you via an email.

If you seek more information, you may contact either myself, my supervisor, or the Human Research Ethics Committee (HREC Non-Medical) telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Katya Nadia Menschy: 2388147@students.wits.ac.za
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