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The Role of Executive Functioning, Motivation, and Engagement in Academic Achievement

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The Role of Executive Functioning, Motivation, and Engagement in Academic Achievement

by

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Abstract

Academic achievement is an important part of healthy development for children and adolescents because of its impact on mental health, wellbeing, and occupational success. Therefore, promoting academic achievement in students of all ages should be a central goal of educational programming. However, to do this, it is essential to first understand what, and how, different factors impact student achievement. Although there are a variety of variables that contribute to academic achievement, executive functioning (EF) and academic motivation and engagement appear to play particularly important roles.

To further explore the relationships between academic achievement, motivation and engagement, and EF, two hierarchical multiple regressions were conducted on a sample of high school students. The Motivation and Engagement Scale – High School (MES-HS) was used to measure the positive and negative aspects of students' motivation and engagement. The Executive Skills Questionnaire – Teen Version (ESQ-T) was used to measure students' EF. Grade point average (GPA) was used to measure academic achievement.

Regarding EF, only working memory and metacognition significantly predicted GPA. This suggests that, of all components of EF, these two are most strongly implicated in academic achievement for high school students. Regarding motivation and engagement, only positive engagement significantly predicted academic achievement for high school students. This suggests that positive engagement plays an important role in academic achievement for high school students.

Preface

This thesis is original, unpublished, independent work by the author, R. Clancy. The experiments reported in Chapters 3-5 were covered by Ethics Certificate number REB21-0329, issued by the University of Calgary Conjoint Faculties Research Ethics Board for the project "Executive Function, Motivation and Engagement: Impact on Academic Achievement" on May 31, 2021.

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List of Abbreviations

ADHD – Attention-Deficit/Hyperactivity Disorder

DV – Dependent Variable

EF – Executive Functioning

ESQ-T – Executive Skills Questionnaire – Teen Version

GPA – Grade Point Average

IV – Independent Variable

MES-HS – Motivation and Engagement Scale – High School

RTI – Response to Intervention

WEIRD – Western, Educated, Industrialized, Rich, and Democratic

WHO – World Health Organization

Chapter I: Introduction

The importance of healthy development in childhood and adolescence has been well documented (Bukvic et al., 2021; Dickson et al., 2018; Domitrovich et al., 2017). Healthy development occurs across a variety of domains, each of which hold unique importance for the current and future outcomes of individuals. For example, social, emotional, and behavioural development can impact wellbeing; physical development can influence mental health; and cognitive development can affect occupational success and acts as a protective factor against some disorders (Dale et al., 2019; Dickson et al., 2018; Domitrovich et al., 2017). Additionally, *academic achievement*, which reflects the development of academic skills and knowledge, is an important component of development (Heckhausen et al., 2010). This is due, in part, to the influence that academic achievement has on a variety of factors, such as mental health, wellbeing, and occupational outcomes in students, and its importance for the mastery of developmental goals (Arnold et al., 2005; Deighton et al., 2018; Duncan et al. 2021; Heckhausen et al., 2010).

Although much of the literature focuses on younger populations, academic achievement continues to be important throughout school (Bas, 2021; Bucker et al., 2018; Jablonska et al., 2019). Specifically, higher levels of achievement are positively implicated with mental health, occupational and educational attainment, and personal and societal wealth. For example, greater achievement is linked with lower rates of mental health challenges and higher levels of confidence, optimism, relational success, and life satisfaction (Duncan et al., 2021; Nordlander & Stensota, 2014; Steinmayr et al., 2016). Occupational and educational attainment are also related to academic achievement, where higher achievement predicts increased years of schooling completed and future income (Duckworth et al., 2012; Watts, 2020). Greater

achievement is also related to increased economic growth within a nation, suggesting that the benefits of improved achievement extend beyond the individual (Cheung & Chan, 2008). In addition to the positive implications of strong achievement, low achievement is also related to negative outcomes. For example, poor readers typically report higher levels of depression, anxiety, and delinquent behaviour, and students with very low achievement are at a greater risk for self-harming behaviours (Arnold et al., 2005; Duncan et al., 2021; Jablonska et al., 2009). Additionally, poor achievement can be a risk factor for behavioural problems and aggression (Savage et al., 2017; Tripathy & Sharma, 2017).

Considering the importance of academic achievement, improving the performance of students in schools will positively impact their current and future lives. Therefore, promoting academic achievement should be an essential component of well-rounded programming in schools. However, to best support academic success, it is essential to first have a clear understanding of the factors that influence and underlie academic achievement in students, as this will provide the foundation for effective research and application. Although many variables can impact academic achievement in students, executive functioning and academic motivation and engagement appear to play a crucial role in supporting academic achievement (Bayoumy et al., 2021; Dawson & Guare, 2012; Martin, 2007; Steinmayr et al., 2019).

Although there is a general understanding that *EF* refers to the higher-order cognitive processes that enable goal-directed behaviour, there is currently a lack of consensus among researchers regarding what specific factors and processes constitute executive functioning (Barkley & Murphy, 2010; Wasserman & Wasserman, 2013). Consequently, a variety of EF frameworks have been put forward, many of which consist of different hypothesized components (Dawson & Guare, 2012; Miyake et al., 2000; Wasserman & Wasserman, 2013). For example,

one prevalent framework separates EF into three stable abilities: shifting, updating, and inhibition (Miyake et al., 2000). Another conceptualization splits EF into hot and cold categories, where *hot EFs* represent skills used in emotionally stimulating situations (e.g., emotional regulation), and *cold EFs* refer to skills that are purely cognitive (e.g., working memory; Rubia, 2011; Zelazo & Muller, 2002). Additionally, Dawson and Guare (2012) posit that, in the context of academics, EF is comprised of 11 malleable academic skills that support student success (response inhibition, working memory, emotional control, flexibility, sustained attention, task initiation, planning/prioritizing, organization, time management, goal-directed persistence, and metacognition). Although various frameworks are useful for understanding EF, Dawson and Guare's academically contextualized framework of EF best fits the current study as this research focusses on academic achievement.

Despite the competing EF frameworks, there is a substantial body of evidence suggesting that EF is related to academic achievement regardless of how it is defined (Langberg et al., 2013; Magalhaes et al., 2020; Pascual et al., 2019). Most of this research has demonstrated that some components of EF (e.g., working memory, flexibility, planning) are related more strongly to academic achievement than others (e.g., emotional control, task initiation; Langberg et al., 2013; Magalhaes et al., 2020). Furthermore, the relationships between the EF components and academic achievement change as students grow older, where a component of EF (e.g., sustained attention) may contribute to achievement in earlier grades but not in later grades (Huizinga & van der Molen, 2007; Magalhaes et al., 2020). Thus, it is essential to examine these relationships across all stages of development, as findings pertaining to one age group may not apply to another.

Furthermore, academic motivation and engagement can also have an important impact on academic achievement in high school students (Collie & Martin, 2019; Martin, 2007; Steinmayr et al., 2019). Although closely connected, academic motivation and engagement are distinct constructs (Martin et al., 2017). *Academic motivation* refers to unobservable, psychological factors that energize a student toward learning (e.g., valuing the task), and *academic engagement* refers to the behaviours that stem from a student's motivation to learn (e.g., persistence; Martin, 2007; Martin et al., 2017). Importantly, academic motivation and engagement can manifest in both positive and negative ways that either promote or hinder school success (Martin, 2007). Therefore, Martin presents a framework for academic motivation and engagement that is comprised of four main facets: positive motivation, negative motivation, positive engagement, and negative engagement. Although many theories on academic motivation exist (e.g., expectancy-value theory and self-determination theory; Ryan & Deci, 2017; Wigfield & Eccles, 2000), Martin's framework provides an integrated, multidimensional representation of academic motivation and engagement because it is derived from a synthesis of several of the core theories of academic motivation (Collie & Martin, 2019).

The importance of academic motivation and engagement has been highlighted throughout the literature (Abdelrahman, 2020; Huang, 2012; Kriegbaum et al., 2015; Martin et al., 2021). For example, positive motivation factors (e.g., self-efficacy, valuing) are linked with greater academic achievement, whereas negative motivation factors (e.g., uncertain control, anxiety) are linked with lower achievement (Abdelrahman, 2020; Huang, 2012; Martin et al., 2018). Furthermore, although far less research has focussed on engagement, similar findings have shown that positive engagement factors (e.g., persistence, planning) are related to greater achievement and negative engagement factors (e.g., self-handicapping, disengagement) are

related to lower achievement (Chase et al., 2014; Collie, Holliman, et al., 2016; Martin et al., 2018). These findings overlap somewhat with the EF research, as certain factors (e.g., persistence, planning, and task management) are implicated in the EF research as well as the motivation and engagement research (Dawson & Guare, 2012).

Meaningful relationships between academic motivation, engagement, and achievement have been found. However, these studies have used conceptualizations that are limited to specific theories of academic motivation and engagement (e.g., expectancy-value theory), and therefore, have excluded important constructs within their study such as self-efficacy, goal orientations, and perceived control (Huang, 2012; Meyer et al., 2019; Plante et al., 2013). Furthermore, the limited number of studies that have applied multidimensional models of academic motivation and engagement have produced mixed results (Bayoumy et al., 2021; Kim et al., 2015; Martin et al., 2018). Therefore, in addition to the lack of research examining the relationship between academic motivation, engagement, and achievement using a multidimensional model, there is also a lack of consensus pertaining to the nature of this relationship.

Considering the impact that academic achievement has on the current and future lives of students, promoting achievement should be a priority. Therefore, acquiring an understanding of the factors that foster academic success will help to inform effective strategies that target the promotion of achievement, which, in turn, supports broad areas. One factor that appears to be central to achievement is EF. Although the relationship between EF and academic achievement has frequently been explored, few studies have examined this relationship in high school students. Therefore, the first aim of this study is to fill this gap in the literature by examining the relationship between EF and academic achievement in high school students. Additionally, academic motivation and engagement have also been identified as important factors related to

academic achievement. However, few studies have used a multidimensional model of motivation and engagement when exploring this relationship, and those that have done so have found mixed results. Therefore, the second aim of this study is to fill this gap in the literature by exploring the relationships between academic achievement, motivation, engagement in high school students using a multidimensional model of academic motivation and achievement.

Chapter II: Literature Review

Academic Achievement

As students progress through school and towards adulthood, there are many important factors that influence their development and future outcomes. Therefore, successful development should be measured across a wide variety of factors and domains (Bucker et al., 2018; Bukvic et al., 2021; Dale et al., 2019; Domitrovich et al., 2017). For example, social, emotional, and behavioural development can have an important impact on the overall wellbeing of an individual (Domitrovich et al., 2017). Physical development is important for the acquisition of motor skills, and physical health and can meaningfully impact an individual's mental health and academic achievement (Bukvic et al., 2021; Dale et al., 2019). Cognitive development can affect academic and occupational success and is a protective factor against some mental health disorders (Biederman et al., 2011; Dickson et al., 2018; Jacob & Parkinson, 2015). Additionally, academic achievement has also been identified as an important component of development. *Academic achievement* reflects the development of academic skills and knowledge and is considered central to the mastery of several developmental goals such as attaining autonomy and competence, especially during childhood, adolescence, and young adulthood (Heckhausen et al., 2010). Interestingly, male and female students typically achieve at different levels, where males achieve higher scores on tests and females achieve higher overall grades (Buchmann et al., 2008). Furthermore, academic achievement influences mental health, wellbeing, and occupational and educational outcomes in students (Bucker et al., 2018; Duckworth et al., 2012; Quinn & Duckworth, 2007; Watts, 2020). This review will focus on the impact of academic achievement on secondary school students, as this population will be the focus of this paper.

Mental Health and Academic Achievement

The World Health Organization (WHO, 2022) defines mental health as a "a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn and work well, and contribute to their community. Although mental health and wellbeing are similar concepts, for the current study, mental health problems refer to clinical symptoms and disorders, whereas wellbeing refers to life quality and satisfaction. Both mental health and wellbeing are relevant to achievement, and both will be addressed below. Research has suggested that there is an important relationship between academic achievement and mental health in secondary school students (Arnold et al., 2005; Bas, 2021). For example, a meta-analysis conducted by Bas synthesized the findings from 13 independent studies that examined the association between mental health and academic achievement in adolescents, finding that there was a small-medium sized association between these factors. Similarly, Duncan and colleagues (2021) found that symptoms of depression are related to academic achievement, where lower ratings of depression are related to higher grades in math and language courses, even after controlling for class attendance and homework completion. Furthermore, other research suggests that academic deficits increase the likelihood of mental health challenges (Francis et al., 2019; Mugnaini et al., 2009). For example, students who are poor readers are at greater risk for mental health problems such as depression, anxiety, and behavioural disorders (Arnold et al., 2005; Francis et al., 2019; Mugnaini et al., 2009). Furthermore, poor academic achievement can predict future self-harming behaviour, where students with the lowest grades are at the greatest risk for self-inflicted injury (Jablonska et al., 2009).

Although the relationship between academic achievement and mental health is complex and not fully understood, much of the research in this area points to a bidirectional relationship between these factors (Deighton et al., 2018; Moilanen et al., 2010; Stanovich, 1986; Stevens et al., 2003). Therefore, considering the research findings and theoretical work in this field, academic achievement appears to play an important role in the mental health of students. Specifically, low academic achievement can act as a risk factor for mental health challenges in students, and high academic achievement can act as a protective factor against mental health challenges in students. These findings further highlight the importance of academic achievement by suggesting that the promotion of academic achievement in students may positively impact their mental health.

Wellbeing and Academic Achievement

Wellbeing refers to how people evaluate the quality of their lives in terms of the extent to which they feel positive and negative emotions and feel satisfied with their lives at global and domain-specific levels (Bucker et al., 2018). Although it is intertwined with mental health, wellbeing does not explicitly describe the presence or absence of symptoms related to mental health problems. Instead, it is more broadly equated to life satisfaction and happiness, where individuals who report higher wellbeing also report experiencing greater satisfaction and happiness, and those who report lower wellbeing also report experiencing less satisfaction and happiness (Kaya & Erdem, 2021). However, like mental health, there appears to be a connection between academic achievement and the general wellbeing of secondary school students (Bucker et al., 2018; Quinn & Duckworth, 2007). Although there are some discrepant findings, much of the literature has demonstrated that wellbeing and academic achievement are positively related (Bortes et al., 2021; Bucker et al., 2018; Duncan et al., 2021). For example, Bucker and

colleagues conducted a meta-analysis examining the relationship between academic achievement and wellbeing in primary school, secondary school, and higher-education students. They found a positive correlation between academic achievement and wellbeing with a small-to-medium effect size that was not moderated by age, gender, country of education, level of education, or method of measurement. Furthermore, other studies have produced similar findings, demonstrating that greater academic achievement is related to higher levels of reported confidence, optimism, success in relationships, and satisfaction in secondary school students (Duncan et al., 2021; Nordlander & Stensota, 2014). Therefore, these findings suggest that there is a relationship between academic achievement and wellbeing; however, they do not point to the direction of this relationship.

Although the direction of this relationship is not fully understood, some research has demonstrated that academic achievement has an impact on the wellbeing of students (Bortes et al., 2021; Steinmayer et al., 2016). For example, Steinmayer and colleagues conducted a longitudinal study to assess the direction of the relationship between academic achievement and wellbeing in German secondary school students. The researchers found that GPA at baseline positively predicted an increase in the life satisfaction ratings of students one-year later but that life satisfaction did not predict later GPA. Furthermore, although research examining secondary school students is limited, research conducted with primary school students shows that academic achievement positively predicts future wellbeing (Quinn & Duckworth, 2007). Taken together, these findings suggest that academic achievement has a long-term impact on the wellbeing of secondary school students.

Future Earnings and Academic Achievement

In addition to the influence of academic achievement on mental health and wellbeing, there is also evidence of a relationship between academic achievement and future earnings of secondary school students (Duckworth et al., 2012; Watts, 2020). For example, Duckworth and colleagues demonstrated that academic achievement predicts school completion and future occupational earnings, where higher achievement is related to increased earnings and number of years of school completed. Furthermore, academic achievement was a stronger predictor of future occupational earnings and years of completed schooling than attention or social skills. Similarly, Watts (2020) showed that math and reading achievement at age 16 is positively related to future occupational earnings after accounting for the influence of health, cognitive abilities, motor and socioemotional skills, and family background, SES, and school characteristics. Although the effect size of this relationship was reduced after controlling for other variables, Watts found that an improvement of one-standard deviation to math and reading achievement scores "predicted approximately 12% more earnings between ages 33 and 50 for both men and women" (Watts, 2020, p. 9). Therefore, these findings suggest that academic achievement can have an important and unique effect on the future occupational earnings of secondary school students.

Taken together, these studies suggest that academic achievement is a significant predictor of future earnings for school-aged students (Duckworth et al., 2012; Watts, 2020). Furthermore, the predictive strength of academic achievement appears to be greater than other school related skills such as attention, behavioural regulation, and interpersonal skills, suggesting that more attention should be focussed on improving student achievement (Duckworth et al., 2012). Considering the existing literature which demonstrates that, up to a certain extent, higher household income predicts improved physical health, mental health, and lower rates of

internalizing and externalizing disorders in children within the household, striving to increase the trajectory of future earnings for students may provide meaningful long-term benefits that extend to future generations (Lansford et al., 2019; McGrail et al., 2009). Consequently, since academic achievement appears to play an important role in future earnings, improving academic achievement can likely promote a variety of positive outcomes in student lives.

Negative Outcomes and Academic Achievement

In contrast to the benefits of greater academic achievement, other research suggests that low academic achievement is connected to a variety of negative outcomes such as problems with conduct, school completion, post-secondary education, health, and acquiring and maintaining employment (Hallerod, 2011; Marks, 2006; Savage et al., 2017). For example, low achievement has been linked with increased rates of violence and conduct problems in adolescents even after controlling for SES and parental education (Savage et al., 2017).

Higher rates of aggressive behaviours have been also linked with lower academic achievement (Tripathy & Sharma, 2017). Although this relationship appears to be bidirectional, Miles and Stipek (2006) propose that students who experience challenges with academics, particularly in reading, are more likely to become frustrated during school and express this frustration through aggressive behaviour directed towards teachers and classmates. Consequently, this may negatively impact the emotional, social, and academic development of these students and may partially explain the relationship between low achievement and aggression. Additionally, low academic achievement negatively impacts school graduation, university acceptance, health, and future occupational outcomes for secondary school students (Hallerod, 2011; Marks, 2006). For example, students who fell in the bottom quartile of achievement in grade 9 were more likely to drop-out of school prior to finishing grade 12, less

likely to attend university, and females were less likely to have full-time employment seven-years later (Marks, 2006). Other evidence suggests that low achievement is linked to economic challenges, higher mortality rates, and problems maintaining employment (Hallerod, 2011). Collectively, these findings suggest that students with low academic achievement are at an increased level of vulnerability for financial, physical, and mental health challenges compared to other students (Hallerod, 2011; Marks, 2006; Savage et al., 2017), emphasizing the importance of promoting academic achievement in students as a strategy for reducing negative outcomes related to conduct, education, health, and occupation.

Societal Impact of Academic Achievement

In addition to the impact of academic achievement at the individual level (e.g., mental health, wellbeing), academic achievement is also relevant at the societal level (Cheung & Chan, 2008). For example, after analyzing data from 33 countries, Cheung and Chan found that country-wide academic achievement scores are an important predictor of occupational and economic outcomes within that country. In this study, the researchers demonstrated that male and female math scores, and female reading scores indirectly predicted the gross domestic product (GDP) per capita in a country. Specifically, higher math and reading scores predicted a higher number of citizens employed in research and development (R&D) and a higher proportion of females employed in the service sector (e.g., transportation, health care, and financial services). In turn, the number of citizens employed in R&D, the proportion of females in the service sector, and the reading achievement scores of students collectively accounted for 67% of the total variance in predicting a country's GDP per capita.

Similarly, Goczek et al. (2021) also demonstrated that student academic achievement is linked to the future economic growth of a country. Specifically, students' scores on standardized

measures of achievement at ages 14 and 15 predicted the GDP of a nation 15 years later, where higher achievement predicted increased economic growth. All areas of achievement (math, reading, and science) were significant predictors of GDP growth. However, math and reading scores were more strongly linked to economic growth than science, indicating that these areas of study are particularly important to the economic wellbeing of a country. These findings suggest that, in addition to its influence at the individual level, academic achievement is also relevant at the national level as it can have an important impact on economic prosperity within a country.

Understanding Academic Achievement

Academic achievement has a substantial impact on the lives of secondary school students, including their mental health, wellbeing, economic success, and behavioural, social, and occupational outcomes. Consequently, promoting student academic achievement is an essential component of well-rounded programming that stimulates positive student outcomes. Thus, developing a thorough understanding of the factors that impact and foster academic achievement in students will be essential in order to effectively guide future research and application. Although the existing literature suggests that many variables influence academic achievement, executive functions and academic motivation and engagement appear to play a particularly central role in students' academic achievement (Bayoumy et al., 2021; Dawson & Guare, 2012; Martin, 2007; Steinmayr et al., 2019).

Executive Functioning

Considering the importance of academic achievement, understanding what skills and abilities support academic success is essential to the goal of improving of student lives. Over recent decades, the topic of EF has gathered attention due to a growing appreciation that EF is

critical for learning and achieving in academics (Diamond, 2013; Duckworth et al., 2019; Jacob & Parkinson, 2015; Wasserman & Wasserman, 2013). EF is particularly important for academics because it facilitates goal-directed behaviours by enabling individuals to prioritize work, inhibit responses, hold relevant information in their mind, switch between tasks, and apply knowledge to make decisions among others (Diamond, 2013). Therefore, EF is foundational to a person's capacity to concentrate, plan, problem solve, organize, and resist temptation (Jacob & Parkinson, 2015). This has led researchers to explore the relationship between EF and academic achievement, and many of which have found that EF plays an important role in predicting student achievement (Duckworth et al., 2019; Sibley et al., 2019; Simone et al., 2018; Trickett et al., 2022).

Executive Functioning Frameworks

Broadly, EF refers to the higher-order cognitive processes that underlie thoughts and behaviours targeted toward achieving a goal (Pascual et al., 2019). EF is a critical component of social, psychological, and cognitive development, as it modulates human cognition and enables individuals to engage in purposeful and future oriented behaviour (Henry & Bettenay, 2010; Miyake et al., 2000; Suchy, 2009; Wasserman & Wasserman, 2013). Although this general understanding of EF is quite widely accepted, many unique frameworks of EF have been put forward in the literature, resulting in a lack of consensus among researchers as to the exact definition or nature of EF (Dawson & Guare, 2012; Miyake et al., 2000; Wasserman & Wasserman, 2013). This has presented a challenge to the field of EF, as a variety of definitions and constructs are prevalent within different frameworks (Suchy, 2009). In general, the two ways to conceptualize EF are through either a *unified* or *diverse* framework (Wasserman & Wasserman, 2013). In unified frameworks, EF is a singular, overarching construct that is

responsible for facilitating a wide variety of functions (Baddeley, 1996). In contrast, diverse frameworks view EF as an umbrella term that encapsulates a cluster of unique processes that enable goal-directed behaviour (Wasserman & Wasserman, 2013). However, most modern conceptualizations of EF integrate the unified and diverse perspectives, describing EF as a cluster of separate, yet connected, processes (Wasserman & Wasserman, 2013).

Unified EF

An early theory of working memory that falls under the unified framework comes from Baddeley (1986), who proposed that, within working memory, there is a system called the central executive that is responsible for coordinating information from the phonological loop and visuospatial sketchpad which are memory systems involved with auditory and visuospatial information. Baddeley theorized that the central executive was responsible for controlling attention, switching between tasks, and inhibiting actions (Baddeley, 1992). Therefore, the central executive was believed to be a singular factor that performed a variety of different functions, representing an early conceptualization of a unified framework of EF. Another theory of EF that falls within the unified framework is provided by Zelazo and colleagues (1997) who put forward a model of EF within the context of problem solving. This model conceptualizes EF as a singular problem-solving system that has four distinct phases of operation: problem representation, planning, execution, and evaluation. Within this theory, EF is a macro-construct that integrates several sub-functions so that these processes can collaborate to achieve higher-order functions (Zelazo et al., 1997). These theories are examples of how EF has been conceptualized as a unified construct.

The unified theories have several strengths and weaknesses. One benefit of these theories is that they help to explain the interconnectedness of EF that is often observed in studies that

divide EF processes into separate components (Miyake et al., 2000; Roth et al., 2013). Additionally, these theories avoid the *task impurity problem*, which refers to how it is very difficult to acquire an unconfounded measure of any specific EF skill (e.g., planning, inhibition). For example, when EF is separated into components, there is a substantial amount of overlap between the components as each individual function requires support from the other functions (Barkley & Murphy, 2010). Some critics, however, argue that a unified EF framework does not explain why some individuals are better at certain EF functions (e.g., switching) than others (e.g., planning). Moreover, these theories do not address the *discriminant validity problem*, which refers to how symptomatically different disorders can all stem from the same EF deficit (Langberg et al., 2013; Pennington & Ozonoff, 1996). This means that if EF is a singular construct, all deficits to EF should result in the same types of disorders, whereas in actuality this is not the case (Pennington & Ozonoff, 1996). Lastly, the unified theories are criticized for their lack of practical application, as a singular EF can only be measured as a single factor (Langberg et al., 2013). This limits the clinical utility of EF findings because they do not have much specificity in relating to how they impact unique tasks such as performance-based EF measures (e.g., TOH and WCST) and academic work (e.g., tests and homework).

Diverse EF

In contrast to a unified perspective, EF can also be conceptualized as an umbrella term for a cluster of separate processes that enable goal-oriented behaviour: through a diverse framework (Pennington & Ozonoff, 1996; Wasserman & Wasserman, 2013). From this perspective, EF is fractionated into a variety of components that are each responsible for carrying out specific functions. The components that are proposed to make up EF vary from theory to theory, but some common examples include working memory, planning, flexibility, inhibition,

attention, and self-monitoring (Miyake et al., 2000; Pennington & Ozonoff, 1996). An early concept of a diversified EF comes from Burgess and colleagues (1998), who found evidence that neuropsychological tests load differently onto cognitive factors and postulated that EF is comprised of three unique factors: inhibition, intentionality, and executive memory. Although there are strengths to this framework, there are also several challenges that arise when attempting to completely fractionate EF.

One major benefit of a fractionated framework of EF is that it provides an explanation as to why an individual's performance on different types of EF tasks can vary. For example, some individuals perform well on certain EF tasks, but not on others (Miyake et al., 2000). Similarly, it addresses the discriminant validity problem because some EF deficits can impact specific EF processes, which can explain why EF deficits in general can result in unique symptoms (Pennington & Ozonoff, 1996). Additionally, it provides better clinical utility because specific EF deficits can be linked to performance deficits which can infer what interventions or accommodations can be put in place for students in schools. In contrast, one problem with a completely fractionated framework of EF is that there is a substantial amount of evidence of overlap among EF factors (Roth et al., 2013). This suggests that the processes involved in EF are largely interconnected, which contradicts a purely diverse perspective. Furthermore, this conceptualization does not explain task impurity, as it should be possible to acquire unconfounded measures of specific EF processes if EF is completely fractionated. This means that, if EF processes are unique, it should be possible to measure each process in isolation without interference from other process. However, this does not appear to be possible, as multiple EF processes always contribute to performance on any EF task (Miyake et al., 2000; Roth et al., 2013).

Unified and Diverse EF

Considering the strengths and weaknesses of both perspectives, theories of a diverse, and unified, EF have become increasingly popular (Miyake et al., 2000). One example of this type of EF framework comes from Miyake and colleagues (2000) who postulated that EF is a collection of separate processes (inhibition, shifting, updating) that work together to enable higher order functions. This framework integrates the unified and diverse perspectives which harnesses many of the strengths from both frameworks, while avoiding some of the weaknesses. For example, a unified and diverse theory of EF explains why task impurity is a challenge and avoids the discriminant validity problem (Wasserman & Wasserman, 2013). Additionally, it explains the interconnections between EF factors while also explaining why individuals may be better or worse at some EF tasks than others (Roth et al., 2013). This provides strong clinical utility for assessing EF because different processes can be linked to specific tasks in daily life (Langberg et al., 2013).

Building on the support for the unified and diverse perspectives of EF, most researchers who have put forward new models of EF have applied this framework (Dawson & Guare, 2012; Rubia, 2011). For example, some researchers posit that EF is distinguishable based on the extent different EFs relate to emotion and cognition (Rubia, 2011; Zelazo & Muller, 2002). This theory suggests that some EFs are considered hot, and some are considered cold (Salehinejad et al., 2021). Specifically, EFs that are displayed during emotionally stimulating situations are called *hot EFs*, encompassing processes such as emotional regulation, delay discounting, and reward processing. Whereas EFs that involve cognitive information processing are referred to as *cold EFs* and include working-memory, cognitive inhibition, and performance monitoring (Salehinejad et al., 2021). Thus, EF processes can be separated into two general domains. This

represents an EF framework that is both unified and diverse as EFs are grouped together due to their similarities yet are still separable as individual processes.

Additionally, EF has also been conceptualized in the context of academics (Dawson & Guare, 2012). For example, Dawson and Guare theorize that EF can be represented as a collection of malleable executive skills that are foundational to learning and achievement in school. These researchers posit that there are 11 academically-relevant executive skills that include planning/prioritization, organization, time management, working memory, metacognition, response inhibition, emotional control, sustained attention, task initiation, flexibility, and goal-directed persistence. Although this framework conceptualizes EF as a collection of distinct processes, like in the diverse perspective, it also posits that many of these processes are similar and can be grouped together, like in the unified perspective (Dawson & Guare, 2012; Strait et al., 2019). Thus, this model represents a unified and diverse framework of EF that is academically contextualized. One strength of this framework is that these executive skills are proposed to relate closely to academic success; therefore, this framework enables educators to identify strengths and weaknesses in students' executive skills and inform academic strategies and interventions (Strait et al., 2019). Furthermore, the proposed malleability of these skills suggests that interventions may have meaningful and lasting impacts (Strait et al., 2019).

There are several EF frameworks that have been put forward in the literature, each with their own strengths and weaknesses. For example, frameworks that fall under the unified perspective best explain the *connections between* EF processes, frameworks that fall under the diverse perspective best explain the *distinction between* these processes, and frameworks that fall under the unified and diverse perspective attempt to harness the strengths of both. Although there are many theories of EF, the current study will use the academically contextualized framework

of EF presented by Dawson and Guare (2012). Considering that a main purpose of the current study is to better understand the relationship between EF and academics, the academically contextualized framework of EF will allow for the clearest connections to be made between EF and academic achievement. Therefore, it is most appropriate for the current study.

Measuring EF

In addition to considerations about the various EF frameworks, researchers and clinicians must also consider how they will measure EF. Currently, both rating scales and performance-based measures are frequently used in research as assessment tools (Toplak et al., 2013). Although the majority of research has historically used performance-based instruments to assess EF, there is a growing conviction that this may not be appropriate (Barkley & Murphy, 2010). This stems from evidence suggesting that rating scales and performance-based measures assess different aspects of EF (Barkley & Murphy, 2010; Toplak et al., 2013). Specifically, Toplak and colleagues posit that "performance-based measures assess processing efficiency of cognitive abilities, whereas ratings of executive function assess the extent to which the individual is achieving his/her goals" (p. 139). Similarly, other researchers suggest that performance-based measures assess a cognitive form of EF (cold), whereas rating scales provide a representation of day-to-day functioning (hot; Barkley, 2011; Barkley & Murphy, 2010). It is important to note that these findings have a potential for bias as some of these researchers are involved in the sale of EF rating scales. These overall findings suggest that the most comprehensive assessment of EF is acquired by measuring EF with both rating scales and performance-based measures (Toplak, 2013).

Although it is best to measure EF using both performance-based and rating scale measurements of EF, there are time and financial constraints to doing so. Consequently, the

current study measured EF using the rating scale from Dawson and Guare's (2012) academically contextualized EF which is designed to assess EF in an academic context. Importantly, since this framework separates EF into components, it provided an opportunity to examine how students' EF strengths and weaknesses contributed to their academic achievement. In turn, this may help to inform more effective interventions and strategies for promoting student success.

Developmental Changes in Executive Functioning

Although it is important to understand how EF relates to academic achievement in general, it is also necessary to consider how this relationship changes throughout development because an individual's EF changes as they mature (Anderson, 2002). Furthermore, these changes do not happen uniformly across all EF skills, instead different EFs have different developmental trajectories, meaning that some processes (e.g., attention) are more fully developed at an earlier age than others (e.g., cognitive flexibility; Anderson, 2002; Best & Miller, 2010). For example, inhibition appears to undergo rapid initial development during the preschool years and then improves at a much slower rate in adolescence. In contrast, the developmental trajectory of working memory and switching are more linear, where gradual improvements are seen throughout preschool and adolescence (Best & Miller, 2010). Other findings suggest that inhibition continues to develop until around age 21, working memory improves until at least age 16 with some evidence of continued development into early adulthood, and planning and shifting skills improve until around age 15 (Huizinga et al., 2006; Luciana & Nelson; 1998; Luciana et al., 2005). In general, these findings show that the developmental trajectories of EF skills vary (De Luca & Leventer, 2008). Although the greatest degree of development occurs in early and middle childhood, changes in an individual's EF

capacity continue to be documented throughout late adolescence and adulthood (Anderson, 2002; De Luca & Leventer, 2008).

Importantly, these changes to EF mean that the way individuals utilize their EF skills to complete tasks will differ depending on their stage of development (Best et al., 2009). Specifically, this suggests that depending on the age of a student, different EF skills may be more or less important for the successful completion of academic tasks. These age-related differences have been exemplified across various age ranges (Huizinga & van der Molen, 2007; Senn et al., 2004;). For example, Senn et al. examined how working memory, inhibition, and shifting abilities contributed to performance on the Tower of Hanoi (TOH) in 2-6-year-old children. Working memory, inhibition, and shifting were assessed using delayed alternation, shape school, and spatial reversal tasks, respectively. The TOH was used as a macro-outcome variable as it requires the use of multiple EFs. Findings from this study revealed age-related differences pertaining to the contributions of the EF components to task performance. Specifically, only inhibition predicted task performance on TOH for participants younger than four, and only working memory predicted task performance on TOH for participants older than four. Similarly, Huizinga and van der Molen demonstrated that the extent to which different EFs contribute to task performance continues to change until early adulthood. Specifically, the authors found age-related changes in performance on the Wisconsin Card Sorting Task (WCST) and the contributions of different components of EF (inhibition, shifting, and working memory) to WCST that performance. Inhibition, shifting, and working memory were assessed using separate task performance measures, namely the Stop-signal, Local-Global, and Tic Tac Toe tasks. Findings revealed that shifting and inhibition scores predicted WCST performance in 7-year-olds, but only shifting predicted performance in 11-year-olds. Furthermore, both shifting and

working memory predicted WCST performance in 15-year-olds, but only working memory predicted WCST performance for 21-year-olds.

Therefore, these findings demonstrate that the extent to which certain EF skills contribute to task performance changes depending on the developmental stage of the individual. For example, elementary aged students will rely on certain EFs when completing academic tasks, whereas high school students may rely more heavily on different EFs for similar tasks (Best et al., 2009). This means that when considering the relationship between EF and academic achievement, it is necessary to also consider the development of the students as this can substantially impact the relationship between these factors (Huizinga & van der Molen, 2007; Senn et al., 2004). Therefore, it will be essential to explore the relationship between EF and academic achievement at all age ranges, as findings from one age group may not generalize to another.

Academic Achievement and Executive Functioning

Considering that the relationships between EFs and task performance change as individuals develop, it is crucial to assess the nature of these relationships at different stages of development. A comprehensive understanding of which EFs, at what age, are most important for academic outcomes may help to determine more effective instructional strategies, accommodations, interventions, and improve overall achievement for students. Fortunately, some researchers have begun exploring this topic and have uncovered meaningful relationships between EF and academic achievement in school-aged children (Langberg et al., 2013; Magalhaes et al., 2020; Pascual et al., 2019). Interestingly, studies that have explored the relationships between EF and academic achievement have demonstrated that not all EF components are equally related to academic achievement (Langberg et al., 2013; Miyake et al.,

2000). Rather, some components of EF are more strongly related to certain academic outcomes than others. However, the majority of this research has focussed on younger students in the elementary and middle school grades (Jacob & Parkinson, 2015).

Academic Achievement and Executive Functioning in Elementary and Middle School

Some evidence of the link between EF and academic achievement is provided by Magalhaes et al. (2020) who demonstrated that not all EF components contribute equally to math and literacy achievement in elementary school children (grades 2-6). Specifically, the researchers found that inhibitory control and attention predicted achievement in grade 2 students, but cognitive flexibility did not account for any additional variance. However, for students in grades 4-6, inhibitory control, working memory, and planning all predicted achievement, and cognitive flexibility was a significant and unique predictor after controlling for other EFs. Interestingly, the contribution of cognitive flexibility to achievement gradually increased as participants matured, where cognitive flexibility was a stronger predictor of math and literacy achievement for students in grade 6 than fluid reasoning, attention, inhibitory control, working memory, and planning. These results suggest that multiple EFs contribute to academic achievement and that some EFs are more strongly related to achievement than others. Furthermore, in alignment with other findings, this study demonstrated that the extent to which EFs contribute to academic achievement in primary school students fluctuates based on the age of the student (Huizinga & van der Molen, 2007; Senn et al., 2004). Specifically, these findings suggest that inhibitory control and attention are particularly relevant to achievement at the early elementary age and that planning, working memory, and cognitive flexibility become more important as students progress into their later elementary years.

Additionally, Langberg et al. (2013) explored the extent to which different components of EF contribute to academic achievement and homework problems in middle school students in grades 6-8 with attentional challenges. Finding indicated that only some of the components of EF significantly contributed to students' GPA and homework problems. For example, only parent and teacher ratings of shifting, planning, and organizing significantly predicted GPA, whereas other variables such as emotional control, inhibition, and working memory did not. Similarly, only parent and teacher ratings of planning and organizing and organization of materials significantly predicted homework problems, whereas many other components of EF did not. These findings suggest that planning, organization, and shifting skills may play a larger role in predicting student academic success during early adolescence than other components of EF.

Taken together, these studies demonstrate that, although EF is meaningfully related to academic achievement in primary and middle school students, not all components of EF are equally related to achievement. Rather, some components are more strongly related to achievement than others. Additionally, these findings demonstrate that, as students develop, the extent that certain components of EF contribute to academic achievement changes. Therefore, this further highlights the importance of exploring the nature of how EF relates to achievement at all stages of student development, as these relationships change with age. Furthermore, considering that EF continues to develop throughout early adulthood, it is important to continue examining these relationships throughout childhood, early and late adolescence, and early adulthood (De Luca & Leventer, 2008; Olson & Luciana, 2008).

Academic Achievement and Executive Functioning in High School

As mentioned, although many studies have examined the relationships between academic achievement and the components of EF in elementary and middle school students, significantly

fewer studies have explored these relationships in high school populations (Duckworth et al., 2019; Langberg et al., 2013; Magalhaes et al., 2020; Pascual et al., 2019). However, there are some studies which have used high school students (Dubuc et al., 2020; Zhao et al., 2019). For example, Dubuc et al. examined the relationship between working memory, inhibition, and academic achievement over a three-year period starting in middle school and ending in high school. They found that improvements in working memory were linked with improvements in achievement for males, whereas improvements in inhibition were linked with improvement in achievement in females. This suggests that the relationship between EF and academic achievement may differ between sexes. Additionally, Zhao and colleagues examined the relationship between metacognition and academic performance, finding that metacognition significantly predicted achievement in a sample of high school students. Therefore, these findings suggest that working memory, inhibition, and metacognition play a role in predicting the achievement of high school students.

Although these are examples of studies that have examined the relationship between EF and academic achievement in high school students, there is limited research in this area. For example, Jacob and Parkinson (2015) conducted a meta-analysis on the relationship between EF and academic achievement, collecting data from 67 studies consisting of both cross-sectional and longitudinal designs and finding that only five (8%) of the studies focused exclusively on adolescents. Results from this meta-analysis indicated that, when grouping the EF components into a single factor, the correlation between EF and achievement was similar across all age groups. However, the contributions of the individual EFs (shifting, working memory, attentional control, and inhibition) were not measured. Therefore, although this study provides evidence that EF remains important across all age groups, it does not specify which components of EF are

most relevant at different ages. Furthermore, Baggetta and Alexander (2016) also noted an underrepresentation of the adolescent population in their systematic review of the EF literature, reporting that, out of the 106 studies used in their review, only 13 (8%) examined EF in relation to an adolescent population. They also found that when comparing the populations studied in different domains (e.g., academics, social functioning, cognitive), only 7% of the studies examining the relationship between EF and academics focused on adolescents (Baggetta & Alexander, 2016). Although the researchers did not provide a summary of the relationship between EF and academic achievement in adolescents or high school students, they did indicate that this relationship appears to change as individuals develop.

Importantly, in addition to the limited number of studies that have focused on adolescents, even fewer have focussed exclusively on high school students. Rather, they have included both high school and middle school students in their samples, making the findings generalizable to adolescents as a whole but not specific to high school students (Escolano-Perez & Bestue, 2021; Latzman et al., 2010; Sibbley et al., 2019). For example, greater deficits in EF, as reported by teachers on the Behaviour Rating Inventory of Executive Function (Second Edition; BRIEF-2), predicted lower academic achievement across all classes for secondary school students (Escolano-Perez & Bestue, 2021). However, the average age of participants in this sample of secondary school students was 13.7 years, which is younger than typical high school students. Furthermore, flexibility, monitoring, and inhibition have been shown to uniquely predict male adolescents' achievement in reading, mathematics, social studies, and science courses after accounting for intelligence (Latzman et al., 2010). However, the adolescent participants used in this sample were between the ages of 11-16 years, and, therefore, are not representative of a typical high school population. Consequently, since these findings do not

apply directly to high school students, little is known about the relationship between academic achievement and EF in high school students.

Exploring Academic Achievement and Executive Functioning in High School Students

EF plays a crucial role in academics for students of all ages (Langberg et al., 2013; Magalhaes et al., 2020; Sibley et al., 2019). EF enables students to engage in goal-directed behaviours which are necessary for learning and completing academic tasks (Diamond, 2013). Although there are a variety of frameworks that have been used to conceptualize EF, an academically contextualized framework is especially useful when examining the impact of EF on academic achievement (Dawson & Guare, 2012). Components of this EF framework include constructs such as planning, working memory, metacognition, flexibility, and more. Unsurprisingly, EF has an important relationship with academic achievement (Langberg et al., 2013; Magalhaes et al., 2020; Sibley et al., 2019). However, most of these findings have been drawn from research that has focussed on children and young adolescents (Best et al., 2011; Langberg et al., 2013; Magalhaes et al., 2020). As a result, there is a lack of research that has examined this relationship in older adolescents, specifically high school students (Jacob & Parkinson, 2015). Therefore, this highlights an important gap in the literature, where there is a clear lack of research dedicated to the examination of the relationships between EFs and academic achievement in high school students. Considering how EF changes throughout development, it is not appropriate to generalize the knowledge of the relationships between EF and academic achievement in younger children to older adolescents. Thus, acquiring a more comprehensive understanding of how EFs relate to academic achievement in high school students is an important next step in this field of research.

Academic Motivation and Engagement

In addition to EF, other variables also play an important role in academic achievement (Collie & Martin, 2019; Steinmayr et al., 2019). In particular, there has been a growing interest in academic motivation and engagement in the fields of education and psychology because of their connection with various academic outcomes, like achievement, enjoyment, buoyancy, and homework completion (Huang, 2012; Martin et al., 2018; Martin et al., 2021; Solomon & Anderman, 2017). Currently, motivational research focuses largely on advancing theoretical understanding of domain-specific motivations, such as hunger, aggression, learning, and sexual desire, as opposed to general theories of motivation that apply to multiple domains (Baumeister, 2016). Therefore, in the context of academic achievement, the current study focuses on motivation as it pertains to academics and learning. Although definitions vary, *academic motivation* typically refers to unobservable, psychological factors that energize a student toward learning such as valuing the task, self-efficacy, and failure avoidance (Reeve, 2012; Schunk & Mullen, 2012). Importantly, research on academic motivation has highlighted the necessity to also consider the role of engagement in the context of learning (Zimmerman & Campillo, 2003). *Academic engagement* can be described as the behaviours, cognitions, and/or emotions that stem from a student's motivation to learn such as planning, persistence, and self-handicapping (Martin, 2007; Reeve, 2012; Schunk & Mullen, 2012). Although academic motivation and engagement are closely interrelated, research has shown that these constructs are distinct from one another (Martin et al., 2017). For example, motivation and engagement are only moderately correlated with each other, they are uniquely predicted by antecedent variables (e.g., age, language, and personality), and uniquely predict outcomes variables (e.g., personal wellbeing, homework completion, and cooperation in the classroom; Martin et al., 2017). Furthermore,

there are both positive and negative manifestations of academic motivation and engagement which have been shown to either promote or hinder a student's ability to achieve in school (Huang, 2012; Martin et al., 2021). For the purpose of this study, *academic motivation* is defined as an individual's energy, drive, and inclination toward learning and achievement, and *academic engagement* is defined as the behaviours that reflect this energy, drive, and inclination (Martin 2007; 2009).

Within the literature, different theories outline aspects of academic motivation and engagement (Cook & Artino, 2016; Pintrich, 2003). These theories attempt to explain how motivation and engagement manifest within the individual and why this is relevant to educational outcomes such as achievement (Collie & Martin, 2019). Although several theories have been particularly influential in the field of academic motivation, due to the complexity of this topic, many of these theories differ substantially from one another (Cook & Artino, 2016). This has resulted in difficulties with the conceptualization and measurement of academic engagement and motivation as there are a multitude of constructs and processes that are implicated within the various theories (Martin, 2007; Pintrich, 2003). These theories will be discussed in the following section.

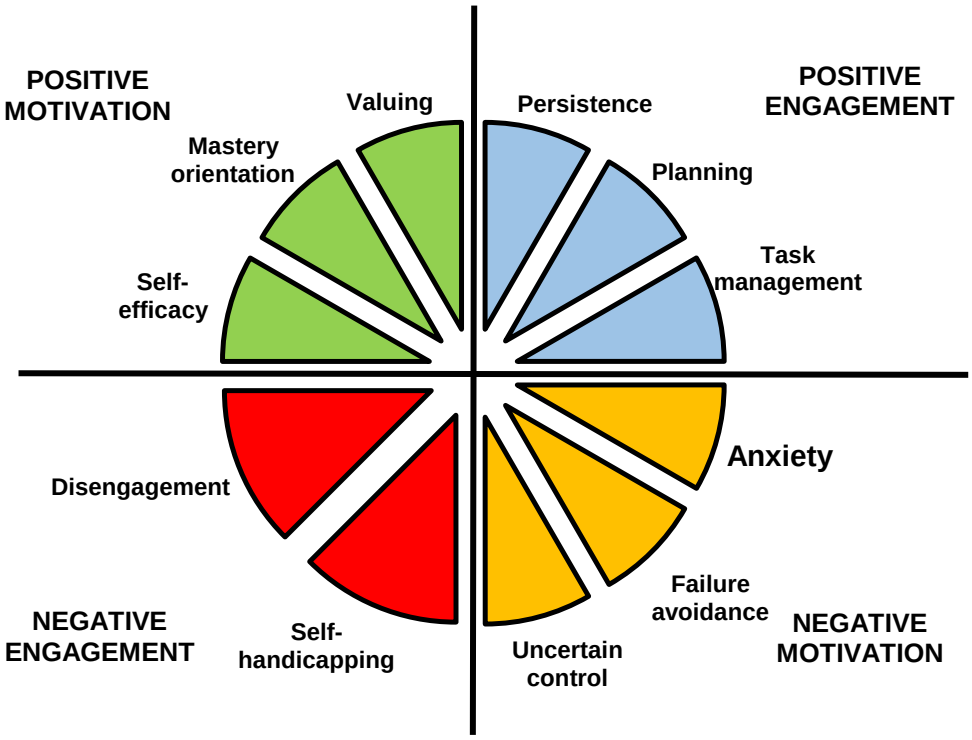
Consequently, researchers have made calls to integrate salient theories of academic motivation and develop an integrated, multi-dimensional framework of academic motivation (Pintrich, 2003). In response to these calls, Martin (2007) argued that many synergies exist across motivational theories that can be synthesized and incorporated into a single, integrated model of academic motivation. Thus, Martin (2007) developed the Motivation and Engagement Wheel, which integrates key motivation and engagement constructs from several of the salient theories of academic motivation.

The *Motivation and Engagement Wheel* represents academic motivation and engagement in terms of their positive and negative impacts on academic outcomes (Martin, 2007). Therefore, the wheel is composed of four broad higher-order factors: positive motivation, positive engagement, negative motivation, and negative engagement (See Figure 1). *Positive motivation* reflects adaptive aspects of motivation that promote positive academic outcomes (e.g., self-efficacy, mastery orientation, and valuing), and *positive engagement* reflects adaptive aspects of engagement that promote positive academic outcomes (e.g., persistence, planning, and task management). In contrast, *negative motivation* represents maladaptive aspects of motivation that impede positive academic outcomes (anxiety, uncertain control, and failure avoidance), and *negative engagement* represents maladaptive aspects of engagement that impede positive academic outcomes (e.g., disengagement and self-handicapping; Martin, 2007). Moreover, each higher order factor is made up of several *lower order factors* that reflect specific constructs within academic motivation and engagement theorizing. Specifically, positive motivation is made up of mastery orientation (desire to achieve competence or mastery over a task), self-efficacy (belief in one's own ability to successfully complete a task), and valuing (the extent that one values a task or outcome). Positive engagement is comprised of planning (the level of planning one undertakes for their schoolwork), task management (the selection of ideal study locations and arrangements), and persistence (continuous efforts and application toward learning and schoolwork). Negative motivation consists of anxiety (feelings of worry that stem from thinking about or engaging in schoolwork), uncertain control (lack of confidence in one's ability to control future academic outcomes), and failure avoidance (desire to avoid disappointing others or looking incompetent). Negative engagement is made up of self-handicapping (behaviours that are used to provide an excuse in case of poor performance) and disengagement (withdrawal of

effort and giving up on performing well in school). Each of the 11 lower-order factors represent key constructs of academic motivation and engagement that were drawn from several of the most influential theories in the field (Collie & Martin, 2019). These constructs and their relevance to theories of academic motivation and engagement are discussed below.

Figure 1

Structure of the Motivation and Engagement Wheel



Note. This figure displays Martin's (2007) Motivation and Engagement Wheel. The Wheel is comprised of 11 first-order factors that are subsumed under four higher-order dimensions. From personal communication with A. Martin & Lifelong Achievement Group, August 8, 2022. Reproduced with permission.

Theories of Academic Motivation and Relevant Constructs

Self-Efficacy and Expectancy-Value Theories

The impact of the appraisals or personal judgements made by individuals about their own competence is frequently discussed in the motivation and engagement literature (Cook & Artino, 2016). Common examples of these appraisals include self-concept, outcome expectancies, and self-efficacy, each of which represent judgements individuals make about their abilities in a given situation (Martin et al., 2017). Self-efficacy has received the most attention in the literature, and therefore, is the only form of appraisal that will be discussed in this section. *Self-efficacy*, which refers to the perception individuals have about their capacity to successfully perform a specific task, has been implicated as a central facet of academic motivation (Bandura, 1982; Martin, 2007). For example, students who have higher levels of self-efficacy typically try harder, persist through challenges, and perform better than students with lower levels of self-efficacy (Bandura, 1982; Schunk & Mullen, 2012). Additionally, students with higher confidence are usually more cognitively engaged in the learning process than students who doubt their abilities (Pintrich, 2003). Therefore, self-efficacy plays an important role in academic motivation, as increased self-efficacy is related to a variety of positive academic factors.

Furthermore, other theories have extended the work on competence appraisals by incorporating factors that work in conjunction with self-efficacy to improve desirable outcomes. For example, expectancy-value theory considers the role of valuing in addition to individuals' perceptions of their competence (Wigfield & Eccles, 2000). Specifically, expectancy-value theory posits that when students have high self-efficacy and perceive the task as something that is beneficial and valuable to them, they are more motivated to engage in the activity and will achieve at a higher level (Martin, 2009; Wigfield & Eccles, 2000). Therefore, the extent to which

students value an academic task can also influence their level of motivation in completing that task. Thus, self-efficacy and valuing are both highlighted as key constructs of academic motivation and are included within the Motivation and Engagement Wheel as positive motivation factors (Martin, 2007).

Attribution and Control Theories

Another salient theory of academic motivation comes from Weiner's attribution theory of achievement (2010), which posits that student motivation is impacted by their beliefs about what caused previous outcomes. Building on this, people explain outcomes by attributing causality of the outcome to themselves or to external circumstances. Individuals attribute causality based on three main axes: stability, locus, and controllability. *Stability* reflects the extent to which individuals believe the cause is consistent across situations and time (e.g., intelligence) versus being temporary (e.g., effort). *Locus* refers to the extent that people perceive the cause as being internal (e.g., ability) versus external to themselves (e.g., task-difficulty). *Controllability* refers to the extent to which students believes that they have the capacity to influence the outcome (e.g., effort) versus being unable to change the result (e.g., luck). Control is of particular importance here because students who perceive that they lack control over their future academic outcomes are uncertain about their ability to achieve success and avoid failure (Martin, 2013a; Weiner, 2010). This is called uncertain control, and uncertain control is negatively associated with class participation, school enjoyment, educational aspirations, mastery orientation, perceived competence, and academic achievement (Liem & Martin, 2012; Martin, 2007). Therefore, uncertain control has important implications for academic motivation and engagement and is included in the Wheel of Motivation and Engagement (Martin, 2007).

Need Achievement and Self-Worth Motivation Theories

Other fundamental work in the academic motivation literature pertains to theories surrounding need achievement and self-worth. Importantly, need achievement and self-worth theories categorize students based on how they orient themselves toward achieving success and avoiding failure (Covington, 2000). These theories suggest that protecting and promoting self-worth is crucial to individuals, thus resulting in two fundamental motives: the drive to approach success and the drive to avoid failure (Covington, 2000). Furthermore, three main student typologies stem from these drives: success-oriented, failure avoidant, and failure-accepting students (Covington, 2000; Martin & Marsh, 2003). *Success-oriented* students are driven by their desire to succeed, are optimistic and energetic about their academic work, and have high levels of self-efficacy and perceived control (Martin, 2013a). *Failure-avoidant* students are motivated by their fear of failure and strive to avoid appearing incompetent. These students may use *self-handicapping* behaviours, which are behaviours individuals engages in that jeopardize their ability to succeed (e.g., procrastination), as a means of excusing poor performance (Collie & Martin, 2019). Furthermore, *anxiety*, which refers to the experience of worry or tension that an individual feels when thinking about or engaging in academic work, often manifests in failure-avoidant behaviours because failure is perceived as threatening to their self-worth (Covington, 2000; Martin, 2007). Lastly, *failure-accepting* students are those who have become indifferent to success or failure and have given up. These students are often referred to as *disengaged*, which is reflective of learned helplessness (Covington, 2000). Success-oriented students typically experience the most positive academic outcomes, whereas failure-avoidant and failure-accepting tendencies are associated with less adaptive outcomes (Covington, 2000). Therefore, in addition to providing support for the relevance of self-efficacy and control, this theory indicates that

anxiety, failure avoidance, self-handicapping, and disengagement are also important constructs of academic motivation and engagement that can negatively impact academic outcomes (Martin, 2007; Martin, 2013a).

Goal Orientation and Self-Regulation Theories

Another central theory of academic motivation is achievement goal theory, which attempts to explain the reasons students strive for achievement (Ames, 1992; Elliot, 2005). Although there has been ongoing theorizing that has extended this model (Elliot et al., 2015), classical goal theory largely focuses on the differences between mastery and performance orientations. Students who hold a *m*astery *orientation* strive to develop their skills, competence, and mastery over a task, whereas students who hold a *performance orientation* are focussed on demonstrating competence and outperforming their peers (Ames, 1992). Although studies examining performance orientation have produced mixed results, mastery orientation has been more consistently linked with self-regulation, deep processing, persistence, interest, choice, and effort (Collie & Martin, 2019; Elliot 2005; Martin, 2013b). Therefore, mastery orientation holds significant importance in academic motivation and is included in the Motivation and Engagement Wheel (Martin, 2007).

Building on this, it is also important to consider how these orientations manifest as behaviours in students' academic lives. Fortunately, self-regulation theories have been helpful in identifying and operationalizing the factors and processes that stem from a student's goal orientation (Martin et al., 2017). For example, Zimmerman and Campillo (2003) proposed that self-regulated learning is comprised of two phases: a forethought phase and a performance phase. Specifically, the *forethought phase* represents the psychological factors that relate to motivation, and the *performance-phase* reflects the action-oriented behaviours and efforts of self-regulation

that relate to engagement. Factors related to the performance phase, such as planning, task management, and persistence, have been frequently identified as important for helping students improve skills, develop mastery, and achieve learning goals (Martin, 2013b; Zimmerman, 2002). Interestingly, there is an overlap between these factors and the components of EF, suggesting that EF is largely implicated in the performance phase (Dawson & Guare, 2012). Furthermore, *planning* (efforts made to plan and monitor progress on academic work), *task management* (students' self-management and organization of their studying activities), and *persistence* (sustained efforts to complete tasks and overcome challenges), have also been linked with greater academic achievement (Martin et al., 2001; Martin et al., 2003). Therefore, self-regulation theories have provided a framework that distinguishes motivation from engagement, and have helped to identify planning, task management, and persistence as key factors of engagement.

Self-Determination Theory

Another salient theory in the academic motivation literature is self-determination theory (Ryan & Deci, 2017). In addition to goal orientation, self-determination theory also relates to mastery orientation through its differentiation between intrinsic and extrinsic motivation (Ryan & Deci, 2017). For example, mastery orientation is conceptually similar to intrinsic motivation because it reflects an internal interest, valuing, and desire to learn, whereas extrinsic motivation comes from external factors such as rewards or grades (Ryan & Deci, 2017). Furthermore, self-determination theory also highlights the importance of psychological needs, including the need for autonomy, competence, and relatedness (Ryan & Deci, 2017). *Autonomy* refers to the need to have control over one's own actions. *Competence* refers to the need to feel capable (e.g., self-efficacy). *Relatedness* refers to the need to feel connected with others. Importantly, intrinsic motivation flourishes in students when their need for autonomy and competence is satisfied, and

intrinsic motivation is inhibited when these needs are not met (Ryan & Deci, 2017). Therefore, the need for competence, which includes self-efficacy, and the need for autonomy, which includes control, are key constructs in academic motivation and engagement.

Integrating Motivation and Engagement

Together, these theories represent some of the most salient models of academic engagement and motivation (Cook & Artino, 2016). By identifying key constructs within these theories and by integrating them into a single framework, Martin (2007) developed an integrated model of motivation and engagement that combines the core components from many of the motivational theories in the literature. The Wheel incorporates positive constructs that represent adaptive aspects of motivation and engagement that promote academic success, and negative constructs that represent maladaptive aspects of motivation and engagement that often hinder academic success (Martin, 2007). Considering the complexity of the motivational literature and the proposed need for an integrated and diverse model of motivation, the Wheel provides a practical and empirically supported tool for measuring academic motivation and engagement in students (Liem & Martin, 2012).

Academic Motivation, Engagement, and Achievement

Many of the studies investigating the relationship between academic motivation and achievement have found that motivation is a significant predictor of academic achievement (Abdelrahman, 2020; Huang, 2012; Kriegbaum et al., 2015). However, many of these studies have operationalized motivation through a framework based on only one or two specific motivational theories, and, therefore, have lacked a comprehensive conceptualization of motivation (Abdelrahman, 2020; Huang, 2012; Plante et al., 2013). For example, Abelrahman,

found that academic motivation accounted for a substantial amount of the variance in academic achievement but only used measures of intrinsic and extrinsic motivation. Similarly, Huang conducted a meta-analysis on studies examining how well achievement goals predict actual academic achievement. Results indicated that mastery goals were associated with positive outcomes such as higher academic achievement and that performance goals were associated with mixed outcomes. Furthermore, Meyer et al. (2019) examined the relationship between academic achievement and motivation from an expectancy-value perspective. They found that expectations and valuing of tasks both significantly predicted students' achievement in math and language arts in terms of their overall grades and performance on standardized tests and final examinations. Although these studies have helped to better understand the importance of the relationship between academic motivation and achievement, they use conceptualizations of motivation that are limited to specific theories and exclude important constructs that may influence the impact of motivation on academic outcomes.

Furthermore, even studies that have included more than one or two models of motivation have often excluded some salient constructs (Kriegbaum et al., 2015; Steinmayr et al., 2019). For example, Kriegbaum and colleagues assessed how well motivation predicted mathematical competence using measures of self-efficacy, interest, and goal-orientation but failed to include constructs from other salient motivational work such as need achievement and attribution theories (Cook & Artino, 2016). Similarly, Steinmayr and colleagues examined the relationship between motivation and academic achievement, finding that all motivation constructs, except performance goals, explained a significant amount of variance in student grades. However, this study only used motivational constructs derived from a limited number of relevant motivational theories. Consequently, Steinmayr and colleagues concluded that it would be beneficial to extend

their findings by including other motivational constructs such as self-efficacy. Therefore, future studies should expand upon these findings by using diverse measurements of motivation that include other salient constructs, such as self-efficacy, to students in a single population.

Additionally, research examining motivation and academic achievement has frequently excluded engagement constructs (Martin et al., 2017). This is problematic considering that motivation and engagement are distinct constructs that are both related to achievement (Chase et al., 2014; Martin et al., 2017). For example, although motivation and engagement share some similarities, they are only moderately correlated with each other, and they are uniquely predicted by antecedent variables such as age, language, and personality. They are also unique predictors of outcomes such as personal wellbeing, homework completion, and cooperation in the classroom (Martin, 2017). Several studies have demonstrated that academic engagement is a predictor of academic achievement, with some findings suggesting that behavioural engagement is a stronger predictor of achievement than cognitive and affective engagement (Chase et al., 2014; Collie, Holliman, et al., 2016). Moreover, self-regulation theories have outlined both forethought (motivation) and performance (engagement) phases as integral components of student learning (Zimmerman & Campillo, 2003). Therefore, by focusing solely on how motivation relates to academic achievement, an important component of this process is being neglected. Considering the calls for research using integrated and diverse frameworks of motivation, future studies that examine the relationship between academic achievement and motivation and engagement should use integrated, multi-dimensional models of motivation and engagement within a single sample (Collie & Martin, 2019; Martin, 2007; Pintrich, 2003).

Research Using Multidimensional Models of Motivation and Engagement

However, despite the limited number of studies examining academic motivation and engagement, some have used diverse frameworks of motivation and engagement to explore their relationship with academic achievement (Bayoumy et al., 2021; Martin et al., 2018; Martin et al., 2021). Interestingly, these studies have produced mixed findings (Bayoumy et al., 2021; Kim et al., 2015; Martin et al., 2018). For example, Martin and colleagues (2021), examined how motivation and engagement predicted a variety of academic outcomes in Indigenous and non-Indigenous students in grades 7 to 9 in Australia. Their findings indicated that there were both similarities and differences pertaining to how motivation and engagement predicted academic outcomes for Indigenous and non-Indigenous students. For example, greater positive motivation and engagement predicted higher levels of academic buoyancy, homework completion, educational aspirations, and academic achievement similarly in both Indigenous and non-Indigenous students. However, negative motivation and engagement did not equally predict academic outcomes among Indigenous and non-Indigenous students. Specifically, for Indigenous students, negative motivation and engagement only predicted lower levels of educational aspirations and homework completion, whereas for non-Indigenous students, negative motivation and engagement predicted lower levels of academic buoyancy, homework completion, educational aspirations, and academic achievement. Although there appears to be some culture differences between groups, these findings indicate that, in general, positive motivation and engagement factors are related to more adaptive academic outcomes and negative motivation and engagement factors are related to more maladaptive outcomes.

Additionally, Martin et al. (2018) examined the relationship between motivation and engagement and enjoyment and achievement in science for students in grades 7-10. Results

indicated that positive motivation and engagement factors, such as self-efficacy, valuing, and persistence, were positively correlated with achievement, and that negative motivation and engagement factors, such as anxiety, uncertain control, and disengagement, were negatively correlated with achievement. Therefore, these studies suggest that positive motivation and engagement are positively related to academic achievement and that negative motivation and engagement are negatively related to academic achievement.

In contrast to these studies, Kim et al. (2015) found mixed results in their examination of student differences in academic motivation, regulation, and engagement in a sample of students attending a virtual high school. Results indicated that group differences between high and low achievers were only present for some of the variables, such as self-efficacy, effort regulation and hopelessness, but not for others, such as valuing and anxiety. These findings contradict those presented in other studies that have also used multidimensional frameworks of motivation and engagement, suggesting that our understanding of the relationship between achievement and motivation and engagement in high school is not clear (Martin et al., 2018; Martin et al., 2021).

Considering the findings from these studies, the literature has produced mixed findings surrounding the relationship between academic achievement and motivation and engagement in high school students. Furthermore, there is a general lack of research examining the role of motivation and engagement in high school students. Consequently, there is a need to conduct further research in this area so that our understanding of motivation and engagement in relation to high school achievement can be improved, as this may lead to an improvement in the services and supports provided to high school students.

Academic motivation and engagement are important factors involved with achievement in school (Huang, 2012; Kriegbaum et al., 2015; Martin et al., 2018). Academic motivation is

exemplified by the drive within students that energizes them toward learning and achievement, and academic engagement is the actions that students undertake to facilitate this drive to learn and achieve (Martin, 2007). Within the academic motivation and engagement literature there are many theories which attempt to explain how motivation and engagement manifest within students (Cook & Artino, 2016). These theories have identified critical components involved in academic motivation and engagement; however, these theories were largely conceptualized in isolation from one another (Pintrich, 2003). Thus, Martin (2007) developed an integrated model of academic motivation and engagement, synthesizing the salient theories in the field and identifying the most central variables that underly academic motivation and engagement. Although many studies have demonstrated that academic motivation and engagement are important for achievement, most of these studies have examined motivation and engagement through the lens of one specific theory (Abdelrahman, 2020; Huang, 2012; Plante et al., 2013). Consequently, these studies have excluded important components of motivation and engagement. Furthermore, the limited number of studies that have used diverse models of motivation and engagement have found mixed results and have been conducted outside of Canada (Bayoumy et al., 2021; Kim et al., 2015; Martin et al., 2018). Therefore, there is a lack of research that has used an integrated framework of academic motivation and engagement to examine its relationship with academic motivation and engagement in high school students. This highlights a gap in the literature that suggests there is a need for further research in this area.

Current Research

To better understand the nature of academic achievement, we examined the role of EF and academic motivation and engagement in predicting the GPA of high school students. By furthering our understanding of the factors that are fundamental to academic achievement, we

can better inform the services, supports, and interventions used to promote achievement in schools. This is an important endeavour because academic achievement is related to many valued outcomes, such as mental health, wellbeing, occupational earnings, and more (Arnold et al., 2005; Bucker et al., 2018; Dale et al., 2019; Watts, 2020). However, there are critical gaps in the literature that need to be addressed. For example, there is a lack of research that has examined the relationships between EF and academic achievement in high school students (Jacob & Parkinson, 2015). This is problematic because EF plays an increasingly important role in academics achievement as students mature (Huizinga & van der Molen, 2007; Senn et al., 2004). Furthermore, there is also a lack of research that has used an integrated framework of academic motivation and engagement when exploring its relationship with achievement. Instead, most studies have examined specific facets of academic motivation and engagement while excluding others (Abdelrahman, 2020; Huang, 2012; Kriegbaum et al., 2015). Consequently, there is a need to examine the relationships between academic achievement, EF, and motivation and engagement.

Research Questions and Hypotheses

The current study examined the relationships between academic achievement, EF, and motivation and engagement. Data was collected from students across two urban high schools within the same school division in Western Canada. Students completed questionnaires regarding their EF and academic motivation and engagement, and GPA was collected from their student files to examine the relationships between these factors.

Question 1: What is the relationship between EF and GPA in high school students?

Hypothesis: EF will predict academic achievement in high school students wherein students with higher EF will earn higher GPAs.

Question 2: What is the relationship between academic motivation and engagement and GPA in high school students?

Hypothesis: Motivation and engagement will predict academic achievement in high school students. Specifically, positive motivation and engagement will positively predict GPA, and negative motivation and engagement will negatively predict GPA.

Chapter III: Methods

Study Design

The primary purpose of this research was to examine the relationships between EF, motivation and engagement, and academic achievement in high school students. This study used a non-experimental, cross-sectional hierarchical linear regression design which examined the relationships between academic achievement, EF (11 variables), and motivation and engagement (4 variables). Survey data was collected from high school students (grades 10-12) from two Calgary high schools. The data was collected as part of a larger study that assessed how teacher professional development on educational neuroscience impacted students and teachers across a variety of areas (well-being, motivation and engagement, school climate, etc.). The data used in this study was collected for the baseline of the larger study.

Ethics

This research study was reviewed by the Conjoint Faculties Research Ethics Board (CFREB) at the University of Calgary (for the full copy of the ethics approval, please see Appendix A). Ethics approval was granted from the University of Calgary for the research and analysis of collected data (Ethics Certificate number REB21-0329).

Written informed consent was acquired from parents/guardians for all participants under the age of 18 years, and assent was acquired online by these participants prior to their engagement in the study. Participants older than 18 years of age provided written informed consent online prior to their engagement in the study. All participants had the opportunity to terminate their engagement in the study at any time up to two weeks after submitting their responses to the survey.

Potential Risks to Participants

The risks to participants were minimal; however, it was possible that students experienced discomfort or boredom while participating. Students were provided with the opportunity to terminate their participation in the study at any time if they wished to stop. Contact information of the researchers, ethics board, and resources for managing distress were provided to the participants in case they had questions or concerns or needed support. Participants were also able to access support through school personnel. No students reported feeling distressed after their participation. Information about individual students and their results were kept confidential.

Participants

Participants in this study consisted of 219 high school students (grades 10-12) from two Calgary high schools with similar demographic compositions. Both school populations consisted of a large proportion of English language learners and ethnically and culturally diverse students that were not representative of a western, educated, industrialized, rich, democratic population group (WEIRD; Henrich et al., 2010). In general, students from both schools came from lower socioeconomic status (SES) households many of whom were required to work outside of school to generate additional income for the family. Additionally, students from both schools were experiencing the COVID-19 pandemic which resulted in a substantial amount of change and uncertain, likely contributing to higher stress levels. Approximately 2,800 students in total from both schools were invited to participate in this study. Initially, there was a total of 490 participants who submitted responses to the survey, 431 (88%) of the respondents were from School 1, and 59 (12%) of the respondents were from School 2. School 1 was the experimental group and received a series of educational neuroscience interventions, which was initiated by the

principal, whereas School 2 was the control group and did not receive any intervention. Therefore, the differences in participation rate may be a result of School 1 having a higher degree of investment in the study. Of the 490 participants who submitted the survey, 123 of these respondents were excluded from this study as they did not complete at least 20% of the survey questions. An additional 145 of the respondents were excluded from the analysis because their grades were not provided. An additional three participants were identified as multivariate outliers and were deleted from the sample. Students who were under the age of 18 were required to provide informed consent from their parents/guardians and assent for their participation, whereas students who were above the age of 18 were required to provide informed consent for themselves.

Demographics

Out of the 219 participants included in this sample, 177 were from School 1 (experimental) and 44 were from School 2 (control). In both schools, participants were enrolled in grades 10-12. Specifically, there were 99 participants in grade 10 (45%), 80 participants in grade 11 (37%), and 40 participants in grade 12 (18%). Most participants in the sample were either male (46%) or female (47%). There was a small group that identified as other genders (6%), and two participants indicated that they preferred not to say (0.01%). The options provided for gender identification were *male*, *female*, *non-binary*, *prefer not to say*, *prefer to identify as* with a blank space to write their gender, and *none of these apply to me.* Participants identified their racial identity by selecting from several options including, *Indigenous/Metis, Asian, Hispanic* or *Latino, Black* or *African, Pacific Islander, White,* or *prefer not to say*. If participants chose more than one option, they were identified as *Mixed Race*. The racial makeup of the sample consisted of Asian (61%), Black or African (10%), White (10%), Hispanic/Latino (7%),

Mixed Race (7%), Indigenous/Metis (1%), Pacific Islander (1%), and seven participants indicated that they preferred not to identify (0.03%). Participants indicated their first language by selecting one of three options including, *English, French,* or *Other*. The breakdown of first languages spoken by participants consisted of English (64%), French (0%), and Other (36%).

Recruitment

Participant recruitment was the same for students from both Calgary high schools. The schools sent a letter home to student's parents/guardians the study, student participation, and consent for their child. Parents/guardians who consented for their child to participate in this study signed the consent form and returned it to the school. The link to the survey was provided to students who had received consent from their parents/guardians or were 18 years of age or older.

Inclusion/Exclusion Criteria. Since the current study focussed on high school students, students needed to be attending high school in grades 10-12 to be included in the study. Additionally, students needed to be enrolled in one of the two high schools that were connected with this study. There was no other inclusion or exclusion criteria.

Informed Consent. Once students accessed the link to the survey, students who were older than 18 years of age were sent to an informed consent webpage that outlined their participation as a voluntary process and described the details of the study, including purposes, procedure, potential risks and benefits, and researcher contact information. Participants who consented clicked the box labeled "I consent" and were redirected to the survey. Participants who did not consent clicked the box labeled "I do not consent" and were redirected to an exit page. Students under the age of 18 who had consent provided by their parents/guardians were

asked to assent to their participations on a similar webpage that outlined their participation as a voluntary process, and described the details of the study, including purposes, procedures, potential risks and benefits, and researcher contact information. The students who provided assent were directed to the survey, and those who did not provide assent were directed to an exit page. Once students began the survey, they had the option to terminate their participation by exiting the survey at any time if they did not want to continue.

Data Collection

This study used data that was previously gathered as part of a larger study (REB20-0581). The larger study was conducted for the purpose of exploring how educating teachers on cognitive neuroscience impacts students and teachers across a variety of variables. Student data collected in the larger study consisted of information pertaining to demographics, academic grades (achievement), executive functioning, academic motivation and engagement, perception of school climate, and mental health. The current study was proposed as an opportunity to further explore the relationships between executive functioning, academic motivation and engagement, and academic achievement (GPA) in high school students. The data that was used in the current study included GPA, gender, grade (academic year), executive functioning, and academic motivation and engagement. GPA was calculated by averaging each participant's marks from all school courses at that point in the year. All data was collected at the beginning of the school year as baseline data for the larger study. Students completed all of the questionnaires at school and during school hours. Students who were English language learners were provided with school supports to ensure that they understood all of the questions.

The data was collected through an online self-report survey using Qualtrics software (Qualtrics, Provo, UT). All information was stored on a secure server at the University of

Calgary which was password protected and only accessible to approved individuals who were a part of the research team. Students who participated in this study were provided with time during regular school hours to complete this survey.

Measures

Executive Skills Questionnaire – Teen Version

Participants completed the Executive Skills Questionnaire – Teen Version (ESQ-T), which is an early version of the Executive Skills Questionnaire – Revised (ESQ-R; Strait et al., 2019). Definitions of EF vary across studies; consequently, for the purpose of this study *EF* is defined as a set of separate, yet connected, higher-order cognitive processes that underly thoughts and behaviours targeted toward the achievement of a goal (Pascual et al., 2019). EFs facilitate higher-level cognitive processes such as problem-solving, reasoning, and decision-making (Diamond, 2013). Consistent with the ESQ-R, scores from the ESQ-T represent 11 executive skills that are applicable to academic contexts: response inhibition, working memory, emotional control, flexibility, sustained attention, task initiation, planning/prioritizing, organization, time management, goal-directed persistence, and metacognition. The ESQ-R and ESQ-T are very similar scales, with the exception that the ESQ-R has a slightly modified item-pool and maps onto five main components that represent an aggregation of the 11 original executive skills components. The current study used the ESQ-T because the wording of the questionnaire was more appropriate for a high school audience. The internal consistency of this measure was assessed using Cronbach's alpha. This measure produced a Cronbach's alpha score of .91, indicating excellent reliability (Tabachnick & Fidell, 2019).

The ESQ-T is a 33-item scale that uses a 7-point Likert scale (1 = *Strongly disagree* to 7 = *Strongly agree*). Each of the 11 Executive Skills is derived from scores on three items, and subscales are interpreted separately rather being combined into a composite score (See Table 1; for a full version of the ESQ-T, please see Appendix B).

Motivation and Engagement Scale – High School

Participants in this study were also asked to complete the Motivation and Engagement Scale (MES-HS) to measure their levels of motivation and engagement in academics (Liem & Martin, 2012). Motivation and engagement are closely related constructs; however, research has shown that they are distinct (Martin et al., 2017). In the context of academics, *motivation* is conceptualized as the unobservable, cognitive aspects of students' orientation toward school that reflect their energy and desire to learn and engage in academics, and *engagement* refers to the observable behaviours stimulated by motivation which reflect students' commitment and conscious effort toward learning (Boulton et al., 2019; Martin et al., 2017; Reeve, 2012). The MES-HS is designed to map students' motivation and engagement based on higher-and-lower-order factors which are represented by the Wheel of Motivation and Engagement (see Figure 1). The MES-HS has been demonstrated acceptable validity and reliability (Liem & Martin, 2012). Cronbach's alpha scores range from an average of 0.77 to 0.79 across studies (Martin & Hau, 2010; Martin et al., 2010). The internal consistency of the measure within the current sample was also assessed using Cronbach's alpha. This measure produced a Cronbach's alpha score of .75, indicating acceptable reliability (Tabachnick & Fidell, 2019). Confirmatory factor analysis has shown excellent fit for the model (Liem & Martin, 2012; Martin et al., 2010). There is also evidence of measurement invariance which indicates that, relevant to the MES, high school

Table 1

Executive Skills Questionnaire – Teen Version

Executive Skill	Definition	Example Questions
Response Inhibition	Suppressing urges to respond to stimuli with a certain action	1. I act on impulse
		2. I get in trouble for talking too much in class
		3. I say things without thinking
Working Memory	Holding and manipulating information in the mind	1. I say "I'll do it later" and then forget about it
		2. I forgot homework assignment or forget to take home needed materials
		3. I lose or misplace belongings such as coats, gloves, sports equipment, etc.
Emotional Control	Managing emotions related to achieving goals	1. I get annoyed when homework is too hard or confusing or takes too long to finish
		2. I have a short fuse or am easily frustrated
		3. I get upset when things don't go as planned
Flexibility	Adapting to changing conditions in order to achieve a goal	1. If the first solution to a problem doesn't work, I have trouble thinking of a different one
		2. I get upset when I have to change plans or routines
		3. I have problems with open-ended homework assignments
Sustained Attention	Maintain focus toward a task despite distractions	1. I have difficulty paying attention and am easily distracted
		2. I run out of steam before finishing homework or other tasks
		3. I have problems sticking with schoolwork or chores until they are done
Task Initiation	Beginning to work on tasks with unnecessary delays	1. I put off homework or chores until the last minute
		2. I have difficulty setting aside fun activities in order to start homework
		3. I need to be reminded to start chores or homework

Planning/Prioritization	Mapping out the steps needed to reach a goal and evaluating the importance of different tasks	1. I have trouble planning for big assignments 2. I have difficulty setting priorities when I have a lot of things to do 3. I become overwhelmed by long-term projects or big assignments
Organization	Implementing and maintaining strategies for keeping track of information and materials	1. My backpack and notebooks aren't organized 2. My desk or workspace at home or school is a mess 3. I have trouble keeping my bedroom or locker tidy
Time Management	Using time effectively and staying within time constraints	1. I have a hard time estimating how long it takes to do something 2. I often don't finish homework at night and may rush to get it done in school before class 3. I need a lot of time to get ready for things
Goal-oriented Persistence	Following through with tasks required to reach goals despite distractions and other interests	1. I can't seem to save up money for a designed object or have problems delaying gratification 2. I don't see the point of earning good grades to achieve a long-term goal 3. I prefer to live in the present
Metacognition	Self-monitoring and self-evaluating progress toward the completion of tasks and goals	1. I don't have very effective study strategies 2. I tend not to check my work for mistakes even when the stakes are high 3. I don't evaluate my performance and change tactics to increase success

Note. This table represents the 11 components of EF as measured by the ESQ-T and provides the definitions of these components and the questions used to measure these components.

students are not significantly different across gender and age group (Liem & Martin, 2012; Martin, 2007). Furthermore, examination of the MES factors in relation to expected outcomes has shown that positive motivation and engagement factors correlate positively to academic enjoyment, aspirations, participation, homework/task completion, and achievement, and negative motivation and engagement factors correlate negatively to these same outcomes (Martin, 2007; Liem & Martin, 2012; Martin & Hau, 2010).

The MES-HS is a 44-item scale that uses a 7-point Likert scale (1 = *Disagree Strongly* to 7 = *Agree Strongly*). Questions on the scale can be mapped onto lower-and-higher-order factors that represent different aspects of motivation and engagement. The higher-order structure of the Wheel is separated into four broad dimensions: *Positive motivation*, representing adaptive cognitive factors that are helpful for learning and task completion; *positive engagement*, representing adaptive behaviours that students engage in to support task completion and learning; *negative motivation*, representing cognitions that inhibit motivated engagement in tasks and learning; and *negative engagement*, representing behaviours that students engage in that are harmful to learning and task completion. Each higher-order dimension is comprised of two to three lower-order factors which collectively make up the lower-order structure of the Wheel (see Figure 1). The lower-order structure is comprised of 11 factors: self-efficacy, mastery orientation, and valuing fall under the positive motivation factor; persistence, planning, and task management fall under the positive engagement factor; anxiety, failure avoidance, and uncertain control fall under the negative motivation factor; self-handicapping and disengagement fall under the negative engagement factor.

Grade Point Average

Information on students' grade point average (GPA) was collected for this study as a measure of students' academic achievement. This was done by taking the mean average of the grades that students achieved in their core subject courses (including religion) from their previous semester. Since this data was collected at the beginning of the school year, students' GPAs reflected their year end grades from their previous year. This meant that for students in grade 10, their GPA was reflective of their year end grades from their junior high school. Office staff compiled the data on the grades achieved by students, and then the researchers selected the core subjects for each student, found their average grade (GPA), and then entered it into the de-identified data file.

Data Analysis

Data Diagnostics

To prepare the data prior to analysis, several steps were taken. The data were assessed for missing values. Any participants who did not have grades (GPA) reported or who had more than 20% of their data missing were removed from the sample. Multiple imputation was used to estimate missing values for any remaining participants who have missing data (Tabachnick & Fidell, 2019). Outliers were identified using mahalanobis values and visual inspection of boxplots. Multivariate outliers were removed from the sample using listwise deletion.

Statistical Software

Statistical analysis of the data was conducted with IBM SPSS Statistics, Version 26 (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.).

Hierarchical Regression

Two hierarchical linear regressions were conducted to examine the relationships between academic achievement, EF, and motivation and engagement. The first regression assessed the relationship between EF and academic achievement while controlling for gender (research question 1). The 11 ESQ factors were used as the independent variables (IVs) to predict GPA as the dependent variable (DV). The second regression assessed the relationship between motivation and engagement and academic achievement while controlling for gender (research question 2). The four higher-order MES factors (positive motivation, positive engagement, negative motivation, and negative engagement) were used as the IVs to predict GPA as the DV. Gender was used as a control variable due to the achievement differences between male and female students (Buchmann et al., 2008).

Assumption testing for hierarchical linear regression was conducted prior to the analysis to confirm that the assumptions were satisfied. All the assumptions were met, except the assumption of multicollinearity. Examination of the variance inflation factors (VIFs) in both regressions indicated that there was moderate collinearity. However, all VIF values were below three, and no bivariate correlations were above .8, indicating that multicollinearity is not severe and does not require corrective measures (Kim, 2019; Yu et al., 2015). The assumptions for hierarchical linear regressions are listed below:

1. The assumption of normality. The errors of prediction are normally distributed around the DV scores.
2. The assumption of linearity. There is a linear relationship between the IVs and DV.
3. The assumption of homoscedasticity. The errors of prediction are relatively equal for all predicted DV scores.

4. Absence of multicollinearity. The IVs are not highly correlated with each other.
5. Independence of errors. Errors of prediction are independent of one another.

Chapter IV: Results

Statistics and Data Analysis

There was a total of 490 participants who submitted responses to the survey. However, 123 of these respondents were excluded from this study as they did not complete at least 20% of the survey questions. An additional 145 of the respondents were excluded from the analysis because their grades were not provided. At this point, there was a total of 222 participants, all of which had less than 20% missing data. To address missing data concerns, the cause of the missing data was first examined. This revealed that the data was not missing completely at random (MCAR), so multiple imputation was used to estimate missing values (Tabachnick & Fidell, 2019). Multivariate outliers were then assessed, and three other participants were deleted as they were identified as multivariate outliers (Tabachnick & Fidell, 2019). Therefore, the final sample for this study consisted of 219 participants (See Table 2 for descriptive statistics).

Table 2

Descriptive Statistics for GPA

Variable	Range		Mean	Standard Deviation	Skewness	Kurtosis
	Minimum	Maximum				
GPA	45.80	95.80	79.03	10.05	-.72	.14

Note. GPA is reported as a percentage and was calculated by finding the mean average of grades in all core classes.

Statistical Analysis of Question 1

Question 1: What is the relationship between EF and GPA in high school students?

Hypothesis: EF will predict academic achievement in high school students wherein students with higher EF will earn higher GPAs.

A hierarchical regression was performed to test if the 11 factors of the ESQ (response inhibition, working memory, emotional control, flexibility, sustained attention, task initiation, planning/prioritizing, organization, time management, goal-directed persistence, and metacognition) predicted GPA when controlling for gender. Prior to the analysis, assumption testing was performed to assess linearity, normality, homoscedasticity, and absence of multicollinearity. The Durbin-Watson test indicated that serial-correlation was not an issue. Examination of the P-P plots of regression standardized residual indicated that the relationship between the IVs and DV were linear. Visual inspection of the scatterplot of standardized residual and standardized predicted values showed constant variation in the residuals. Visual inspection of the histogram suggested that error distributions were approximately normal. Multicollinearity was assessed using bivariate correlations, tolerance, and variance inflation factor (VIF) statistics. Although correlations between IVs were not extremely high, low tolerance values and moderate VIF values suggest that a moderate level of multicollinearity may be present. Although moderate collinearity is not likely to significantly impact the regression coefficients and is not severe enough to require corrective measures, these results should be interpreted with caution. Gender was entered in the first block and was not found to be a significant predictor of GPA, $F(3, 215) = 0.399$, $p > .05$, explaining 0.6% of the variance. When gender was held constant, the 11-factor model significantly predicted GPA, $F(14, 204) = 2.338$, $p = .002$, and explained 13.3% of the unique variance in the model. Working memory ($\beta = .241$, $p = .024$), and metacognition ($\beta = .234$, $p = .022$) were the only significant predictors (see Table 2). See Table 3 for the correlations between variables.

Table 3

Correlations for EF Variables and GPA

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. GPA												
2. Inhibition	.14*											
3. Working Memory	.26**	.54**										
4. Emotional Control	.04	.30**	.45**									
5. Flexibility	.01	.22**	.40**	.64**								
6. Attention	.16*	.34**	.62**	.48**	.55**							
7. Task Initiation	.23**	.27**	.64**	.42**	.34**	.64**						
8. Planning	.17**	.30**	.53**	.47**	.61**	.64**	.54**					
9. Organization	.11	.34**	.56**	.33**	.27**	.38**	.52**	.35**				
10. Time Management	.18**	.33**	.55**	.50**	.51**	.59**	.56**	.64**	.47**			
11. Persistence	.16**	.32**	.45**	.37**	.39**	.45**	.44**	.44**	.45**	.58**		
12. Metacognition	.28**	.35**	.58**	.45**	.50**	.62**	.62**	.63**	.43**	.57**	.56**	

Note. This table represents the correlations among GPA and the EF components.

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

Statistical Analysis of Question 2

Question 2: What is the relationship between academic motivation and engagement and GPA in high school students?

Hypothesis: Motivation and engagement will predict academic achievement in high school students. Specifically, positive motivation and engagement will positively predict GPA, and negative motivation and engagement will negatively predict GPA.

Table 4

Hierarchical Regression for EF and GPA

Variable	*B*	95% CI for B		*SE B*	β	R^2	ΔR^2
		LL	*UL*				
Step 1						.01	.01
Constant	81.00	61.11	100.90	10.09			
Male	-2.47	-22.46	17.53	10.14	-.12		
Female	-1.29	-21.27	18.71	10.14	-.06		
Other	-3.68	-24.22	16.87	20.42	-.09		
Step 2						.14*	.13*
Constant	73.79	53.47	94.11	10.31			
Response Inhibition	-0.09	-0.55	0.379	0.24	-.03		
Working Memory	0.54	0.07	1.00	0.24	.24*		
Emotional Control	-0.14	-0.57	0.28	0.22	-.06		
Flexibility	-0.49	-1.00	0.02	0.26	-.19		
Sustained Attention	-0.14	-0.61	0.34	0.24	-.06		
Task Initiation	0.06	-0.37	0.50	0.22	.03		
Planning/Prioritizing	0.14	-0.32	0.59	0.23	.06		
Organization	-0.24	-0.65	0.17	0.21	-.10		
Time Management	0.17	-0.31	0.65	0.24	.07		
Persistence	0.08	-0.43	0.59	0.26	.03		
Metacognition	0.55	0.08	1.02	0.24	.23*		

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

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

A hierarchical regression was used to test if the four higher-order factors of the MES (positive motivation, positive engagement, negative motivation, and negative engagement) predicted GPA when controlling for gender. Before conducting the regression, testing was conducted to assess whether there were violations to the assumptions of linearity, normality,

homoscedasticity, and absence of multicollinearity. No assumptions were violated with the possible exception of multicollinearity. Examination of the bivariate correlations, tolerance, and VIF statistics indicated that moderate multicollinearity may be present. Although moderate collinearity is not likely to significantly impact the regression coefficients and is not severe enough to require corrective measures, the results should be interpreted with caution. Gender was entered into the first block and was not found to be a significant predictor of GPA, $F(3, 215) = 0.399$, $p > .05$, explaining 0.6% of the variance. When gender was held constant, the model of the four MES factors predicted GPA, $F(7, 211) = 2.570$, $p = .015$, and explained 7.3% of the unique variance in the model. Only positive engagement ($\beta = .197$, $p = .048$) was a significant predictor (see Table 3). See Table 5 for the correlations between variables.

Table 5

Correlations for Motivation and Engagement Variables and GPA

Variable	1	2	3	4	5
1. GPA					
2. Positive Motivation	.20**				
3. Positive Engagement	.26**	.72**			
4. Negative Motivation	-.07	-.18**	-.24**		
5. Negative Engagement	-.21**	-.47***	-.49**	.54**	

Note. This table shows the correlations between GPA and the motivation and engagement components.

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

Table 6

Hierarchical Regression for Motivation, Engagement and GPA

Variable	*B*	95% CI for B		*SE B*	β	R^2	ΔR^2
		LL	*UL*				
Step 1						.01	.01
Constant	81.00	61.11	100.90	10.09			
Male	-2.47	-22.46	17.53	10.14	-.12		
Female	-1.29	-21.27	18.71	10.14	-.06		
Other	-3.68	-24.22	16.87	20.42	-.09		
Step 2						.08*	.07*
Constant	72.88	48.35	97.41	12.44			
Positive Motivation	-0.01	-0.16	0.15	0.08	-.01		
Positive Engagement	0.14	0.00	0.28	0.07	.20*		
Negative Motivation	0.03	-0.06	0.13	0.05	.06		
Negative Engagement	-0.09	-0.19	0.02	0.05	-.15		

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

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

Chapter V: Discussion

Academic achievement is an important factor to consider in the educational context due to its influence on the current and future lives of students. For example, academic achievement is linked with mental health, wellbeing, occupational success, societal wealth, and more (Bucker et al., 2018; Cheung & Chan, 2008; Deighton et al., 2018; Watts, 2020). Therefore, understanding what factors facilitate academic achievement and how to promote it in students may provide an opportunity for the improvement of a variety of life outcomes for students. Executive functioning and academic motivation and engagement are factors that have already been identified as central to learning and achieving in academics (Bayoumy et al., 2021; Dawson & Guare, 2012; Martin, 2007; Steinmayr et al., 2019). However, much of the research that has explored these links has been done using younger samples of students. Consequently, there is a lack of research that has examined the relationship between EF, academic motivation and engagement, and academic achievement in older students. The current study sought to fill this gap by examining these relationships in high school students. The following sections will review each of the research questions, their findings, and what they mean.

The Role of EF in the Academic Achievement of High School Students

The first goal of the current study was to answer the question: What is the relationship between self-reported EF (as measured by the ESQ-T) and academic achievement (GPA) in high school students. I predicted that there would be a significant relationship between EF and academic achievement in high school students, where higher EF scores would predict higher achievement. This hypothesis was partially supported by the results of the hierarchical regression, which demonstrated that, together, the 11 components of EF significantly predicted academic achievement. However, when examining each component of EF in isolation, only

working memory and metacognition significantly contributed to the model. This suggests that working memory and metacognition play a particularly important role in academic achievement for high school students.

Despite a lack of research using samples of high school students, the current findings indicating that, as a whole, EF significantly predicts academic achievement is generally aligned with research that has explored this relationship in younger students (Jacob & Parkinson, 2015; Pascual et al., 2019). Therefore, the current study extends upon what is known about the importance of EF for academic achievement in elementary and middle school students by providing evidence that EF continues to remain relevant throughout high school. However, considering that only working memory and metacognition were significant predictors of academic achievement when looking at the individual contributions of the EF components, this suggests that not all components of EF are equally related to academic functioning. Rather, these findings provide evidence that working memory and metacognition play a particularly important role in achievement. The following section will describe and interpret how the current study aligns and differs from other work in this area.

Significant Predictors of Academic Achievement in High School Students

Working Memory. Considering working memory, our findings align with what has frequently been demonstrated in the literature, which is that working memory is significantly related to academic achievement (Ahmed et al., 2018; Jacob & Parkinson, 2015; Pascual et al., 2019; Simone et al., 2018). However, this study extends upon the existing literature, which has focused mostly on elementary and middle school students, by providing evidence that this relationship continues to remain significant in high school students. Therefore, the current findings suggest the ability to hold and manipulate information in one's mind while completing

complex tasks is central to the acquisition and application of academic skills and knowledge. This is not surprising considering that students are frequently required to remember information, instructions, and sequences in the academic context. Consequently, students with working memory deficits frequently experience challenges keeping track of their progress throughout tasks, performing mental arithmetic, and remembering and carrying out instructions (Gathercole et al., 2006). Moreover, students with working memory deficits may experience academic challenges as a consequence of their inability to meet the memory demands of many learning activities (Gathercole et al., 2006). This can result in an overloading of their working memory which may lead to students losing track of task-relevant information and consequently lacking the necessary information to complete their tasks (Gathercole et al., 2008). Therefore, well-developed working memory supports students' ability to effectively learn and complete academic tasks, whereas deficits in this area will hinder learning and achievement.

Although some studies have found contrasting evidence indicating that working memory is not related to academic achievement, these findings are less common and have often been reported in studies using younger elementary students in their sample (Magalhaes et al., 2020; Rutherford et al., 2018). Thus, this may suggest that working memory becomes more relevant in academics as students advance through their schooling years and are exposed to more complex topics and tasks (Magalhaes et al., 2020). Additionally, this may reflect differences in the developmental trajectories of EF, as working memory develops more gradually than other components (e.g., inhibition) and, therefore, younger students may not have the capacity to use it as effectively (Anderson, 2002; Best & Miller, 2010).

Metacognition. In the case of metacognition, findings from the current study align with the existing literature, confirming that metacognition plays an important role in learning and

achievement in adolescents (Abdelrahman, 2020; Ohtani & Hisasaka, 2018; Sibley et al., 2019). Metacognition refers to students' ability to observe themselves objectively, evaluate their own behaviours, and adjust their future behaviours based on past learning (Dawson & Guare, 2012). Therefore, conceptually, metacognition is central to the process of learning and achieving because it enables students to interpret the effectiveness of their actions and use that knowledge to better conduct themselves in the future. Furthermore, metacognition may become more important as students progress into their later school years because the expectations surroundings student independence and personal responsibility progressively increase, leading to a greater importance for self-regulated learning (Jacobson et al., 2011; Langberg et al., 2013). Importantly, metacognition appears to mediate the relationship between other EF components and self-regulated learning for students in independent learning environments (Follmer & Sperling, 2016). Thus, the ability to reflect upon one's own strategies and critically evaluate their effectiveness may compensate for the reduction in support which is typical of high school environments. Considering other evidence showing that metacognition is significantly related to achievement for grade 9 (Abdelrahman, 2020) and college (Sibley et al., 2019) students, it is unsurprising that this relationship is also seen at the high school level. Therefore, the current findings align both conceptually and empirically with the previous literature. Additionally, considering that this relationship has not been previously explored in high school students, the current study extends upon the existing knowledge by providing evidence that metacognition predicts academic achievement in high school students.

Therefore, the importance of metacognition for learning and achievement in high school may suggest that improving metacognitive skills in high school students will support and promote academic achievement. This notion is supported by studies which have found that

students who received metacognitive interventions achieved higher grades following the intervention (Dignath & Buttner, 2008; Duckworth et al., 2011; Duckworth et al., 2013). Specifically, some of these metacognitive interventions focussed on supporting students to develop an awareness of their academic goals, identify obstacles and challenges that may arise in pursuit of these goals, and outline strategies to overcome these obstacles (Duckworth et al., 2011; Duckworth et al., 2013). Other interventions focussed on increasing students' knowledge of metacognitive strategies and the benefits that they provide (Dignath & Buttner, 2008). Importantly, Dignath and Buttner found that metacognitive interventions were more effective for secondary school students than primary school students, hypothesizing that this was due to underdeveloped metacognitive abilities in primary school students. Therefore, this suggests that as students mature, they rely more on metacognition and may benefit more from metacognitive supports and interventions.

Non-Significant Predictors of Academic Achievement in High School Students

Aside from working memory and metacognition, the other EF components were not significant predictors of academic achievement. These findings indicate that self-reported ratings of emotional control, planning/prioritization, flexibility, organization, task initiation, sustained attention, response inhibition, goal-directed persistence, and time management do not predict achievement in high school students. For some variables, this non-significance comes as a contradiction to what has been shown previously in the literature, whereas for other variables these findings are congruent with the previous work or have not yet been thoroughly explored.

Unexpected Findings. Considering that planning, sustained attention, goal-directed persistence, time management, and inhibition have been linked to academic achievement in the past, the current findings come as somewhat of a surprise (Langberg et al., 2013; Magalhaes et

al., 2020; Trickett et al., 2022). In the context of planning, as students progress into their later school years, achievement becomes more influenced by a small number of large exams, long-term projects, and writing assignments (Langberg et al., 2013). This type of work typically requires more planning, which would suggest that the ability to develop plans to manage one's actions over time becomes increasingly important as students transition into their later schooling years (Jacobson et al., 2011). Although much of the previous research has focused on elementary and middle school students, it would be reasonable to expect that the impact of planning on achievement in high school would be similar, if not greater. Therefore, the current findings contradict the trends and rationale reported in previous research (Langberg et al., 2013; Magalhaes et al., 2020).

One explanation for this may come from differences stemming from the sources used to acquire EF ratings. For example, Langberg and colleagues used parent and teacher ratings of students' planning skills, whereas the current study used a self-report measure. Thus, discrepancies between self-report and parent/teacher-report measures may explain the different findings because students may perceive their planning skills differently to their parents and teachers (Venetz et al., 2019; Zabel et al., 2011). Furthermore, some of the evidence suggesting that there is a significant relationship between planning and achievement comes from a study which measured achievement in specific subject areas such as math or literacy rather than overall GPA (Magalhaes et al., 2020). Therefore, another possible reason for differences in findings may be due to measurement differences of the dependent variable, suggesting that planning skills may be more relevant to some subjects (e.g., math) than others (e.g., literacy). Additionally, the instrument used to measure planning in the current study consisted only of three items. This may have resulted in scores that do not comprehensively represent students' planning abilities, and

therefore, these differences may be due to measurement challenges. However, despite these possible explanations, due to the mixed findings in the literature and the lack of research assessing high school populations, our current understanding of the relationship between planning and academic achievement in high school students is insufficient. Thus, there is a need for further exploration in this area, especially pertaining to the use of self-reported measures and specific courses versus overall cumulative grades.

The majority of the literature examining the relationship between time management and achievement has reported finding significant relationships with varying effect sizes (Cemaloglu & Filiz, 2010; Liu et al., 2009; Razali et al., 2018). Although there is limited research examining high school students, studies have demonstrated that this relationship remains significant in middle school (Liu et al., 2009) and post-secondary school students (Cemaloglu & Filiz, 2010; Razali et al., 2018). This suggests that time management should also be an important factor related to achievement in high school students. However, the majority of this research has been correlational rather than predictive. Therefore, the current findings may extend upon the existing literature by indicating that although time management and achievement are correlated, time management alone does not predict achievement. However, due to the lack of research that has examined the relationship between time management and achievement using regression analyses, there is a need to further explore this relationship in high school students.

Furthermore, the current findings, which indicate that goal-directed persistence does not predict achievement, differ from previously reported findings (Fang et al., 2017; Meindl et al., 2018). For example, Meindl and colleagues, who equate goal-directed persistence to frustration tolerance, demonstrate that high school students' persistence predicted GPA, standardized test scores, and progress toward college degrees up to 2-years later. Furthermore, Fang and

colleagues found that persistence was related to achievement in online courses. However, this relationship was only found to be significant for some of the courses and not for others. Therefore, one possible explanation as to why the current results contrast what is shown in the literature stem from how academic achievement was measured. For example, while the current study examined student GPA across all classes, previous studies have used grades from specific classes. Another possible explanation may come from measurement differences of the independent variable, where frustration tolerance and goal-directed persistence may not represent identical constructs. Regardless, there is a need for researchers to continue exploring this topic.

Finally, although the literature indicates that inhibition and attention are both related to academic achievement (Jacob & Parkinson, 2015; Latzman et al., 2010; St. Clair-Thompson & Gathercole, 2006; Trickett et al., 2022), the results of the current study suggest that this is not the case. Thus, these findings appear to be in direct contrast to those from previous studies. However, it is important to consider that previous studies have largely focussed on elementary and middle school populations, while mostly excluding high school students except for some partial overlaps in the age range (e.g., 11-16 years old; Latzman et al., 2010). Therefore, one explanation for the findings may stem from the possibility that inhibition and attention relate differently to academic achievement in high school students than in elementary and middle school students. Specifically, this suggests that these variables play a more important role in achievement for younger students compared to older students. Some evidence in support of this claim comes from research that has outlined the developmental trajectories of EF, indicating that inhibition and attention are among the earliest to develop (De Luca & Leventer, 2008). Thus, this may suggest that although inhibition and attention have a greater impact on learning and achievement in younger students, these skills may not be sufficient for learning and achievement

as students grow older. Instead, high school students may rely more heavily on higher-level functions such as working memory and metacognition to accommodate for the increased complexity of their work. However, considering that there is a lack of research exploring this area in high school students, there is a need to continue researching this relationship so that these findings may be replicated or refuted.

Other Findings. For the remaining non-significant factors (emotional control, task initiation, flexibility, and organization), the current findings do not directly contradict what has been shown in previous research. For example, although emotional control is relevant to achievement and learning as it relates to students' regulatory skills and behaviours, other studies have also reported that it is not a significant predictor of achievement (Langberg et al., 2013). This suggests that, despite a link between the two variables, emotional control does not contribute substantially to academic achievement in high school students. Similarly, the current findings, which indicate that task initiation does not predict achievement, are congruent with previous research (Sibley et al., 2019). Although task initiation intuitively appears to be vital for school success, these findings demonstrate that it is not sufficient to directly predict achievement on its own. Therefore, despite some relationship between academic achievement and emotional control and task initiation, these results suggest that neither variable plays a substantial role in academic achievement for high school students.

Furthermore, although the ability to organize and manage materials and information has been previously implicated in the academic context, organization skills have been linked with homework completion rather than with academic achievement directly (Langberg et al., 2011; Langberg et al., 2013). Therefore, although organizational skills appear to be important for academics, they are not as strongly related to grades as they are to other aspects of successful

school functioning (Langberg et al., 2013). Thus, the current findings align with what has been demonstrated in the literature. However, there are important differences between the current study and the previous research. For example, previous studies have only examined this relationship in younger students and not in high school populations. Furthermore, the current study assesses students' organizational skills using a self-reported measure rather than parent-or teacher-reported measures like in previous studies (Langberg et al., 2011; Langberg et al., 2011). This is important to note, because students with deficits in attention and organizational skills (as rated by teachers and parents), have been shown to rate their own attention and organizational skills as normal (Langberg et al., 2011). This suggests that self-reported measures, like the one used in the current study, may not accurately measure a student's organizational skills when that student has deficits in that area. Furthermore, considering that academic work becomes increasingly complex in later grades, requiring a higher degree of self-regulated learning (Rutherford et al., 2018), organizational skills may play a more important role for students in high school. Therefore, although the current findings align with previous research on younger students, it will be important to re-examine this relationship in high school students using parent or teacher ratings of students' organizational skills.

Finally, although there is evidence which points to a link between flexibility and academic achievement, the results from the current study indicated that this relationship was not significant (Collie et al., 2017; Feraco et al., 2022; Sheriston et al., 2019). Although these findings appear contradictory, there are important nuances regarding this relationship which make these results unsurprising (Collie et al., 2017; Feraco et al., 2022). Importantly, the current study conceptualizes flexibility as a representation of a student's ability to adapt to unexpected changes and obstacles while pursuing an academic goal (e.g., an unexpected problem occurs

when completing a school assignment). This definition is different from many other studies which conceptualize flexibility as the ability to switch between rule sets and cognitive frameworks (Magalhaes et al., 2022; Sibley et al., 2019). Therefore, the current definition of flexibility aligns closely with the term adaptability. These terms will be used synonymously moving forward. Although previous studies have demonstrated that there this is a link between flexibility/adaptability and academic achievement, the relationship is mediated by other variables such as engagement, self-efficacy, and self-regulated learning strategies (Collie et al., 2017; Feraco et al., 2022; Sheriston et al., 2019). Thus, the current findings align with previous studies and support the notion that flexibility/adaptability is not directly related to academic achievement but rather, is related indirectly through mediating variables (Collie et al., 2017).

EF and Academic Achievement

Overall, these findings suggest that working memory and metacognition are significant predictors of academic achievement in high school students and are more strongly implicated in academic achievement than other executive functions. Therefore, when implementing interventions and accommodations for high school students, educators should consider ways to support the metacognitive and working memory abilities of students, as these play an important role in achievement. Furthermore, researchers should continue to explore the roles of other EFs in the academic achievement of high school students, as these areas have not been thoroughly explored in this population.

The Role of Academic Motivation and Engagement in the Academic Achievement of High School Students

The second goal of this study was to answer the question: What is the relationship between self-reported academic motivation and engagement (as measured by the MES-HS) and academic achievement (GPA) in high school students? I predicted that there would be a significant relationship between academic achievement and both academic motivation and engagement in high school students. Specifically, I hypothesized that motivation and engagement scores would predict achievement, where higher positive motivation and engagement scores would predict higher achievement and higher negative motivation and engagement scores would predict lower achievement. This hypothesis was partially supported by the results from the hierarchical regression which indicated that, together, the four motivation and engagement variables significantly predicted academic achievement. However, when examining the separate contributions of each factor, only positive engagement was a significant predictor of academic achievement. Therefore, this suggests that positive engagement is particularly important for academic achievement in high school students.

Although the relationship between academic achievement and motivation and engagement in high school students has been previously explored, few studies have done so using a multi-component model of academic motivation and engagement. Furthermore, few studies have explored this relationship within a culturally and ethnically diverse sample. Therefore, the current study expands upon the existing literature by demonstrating that the relationship between academic achievement and motivation and engagement remains significant in diverse populations when measuring motivation and engagement through a multi-component framework. However, considering that when looking at the individual contributions, positive

engagement was the only significant predictor, this suggests that positive engagement plays a particularly important role in academic achievement. The following section will interpret these findings in relation to the existing literature.

Predictors of Academic Achievement in High School Students

Positive Engagement. As expected, the current study found that positive engagement is a significant predictor of academic achievement in high school students. These findings are congruent with previous research as they align with the majority of literature examining the relationship between academic engagement and achievement (Chase et al., 2014; Collie, Holliman, et al., 2016; Martin et al., 2021). This suggests that persistence, planning, and task management are important factors related to the grades that high school students achieve. This is not surprising considering that the academic context in high school consists of heightened need for personal responsibility and self-regulated learning (Jacobson et al., 2011; Langberg et al., 2013; Zimmerman, 2002). Therefore, high school students who are better able to persist through setbacks, plan out their course of action, and manage their learning strategies and environments will achieve at higher levels.

Interestingly, positive engagement is made up of factors that are similar to those included in the EF measure that were not found to be significant predictors of academic achievement. There are a few possible explanations for this. First, positive engagement combines three lower-level components. This may suggest that persistence, planning, and task management do not predict achievement in isolation, but when combined, these factors cumulatively account for enough variance to be considered a significant predictor. Another possible explanation is that there are differences between the instruments used to measure EF and motivation and engagement. For example, the EF measure only uses three items per component, whereas the

motivation and engagement measure uses four. This may suggest that the motivation and engagement instrument provides a more comprehensive measurement of persistence, planning, and task management, which could explain why these variables significantly predicted achievement in one measure but not in the other.

Although the current findings are congruent with most other studies that have examined this relationship, there is some evidence suggesting that academic engagement does not predict academic achievement (Bayoumy et al., 2021; Boulton et al., 2019). However, rather than discounting the relationship between achievement and engagement in general, these contrasting findings suggest that the type of engagement is important to consider. For example, although findings pertaining to how cognitive (e.g., mental effort and thinking strategies) and affective (e.g., emotion felt toward school) engagement relate to academic achievement are mixed, behavioural engagement is a strong and consistent predictor of achievement (Bayoumy et al., 2021; Boulton et al., 2019; Chase et al., 2014). Thus, the previous literature suggests that, while cognitive and affective engagement are not reliable predictors of achievement, behavioural engagement is. Although the current study does not address cognitive or affective engagement, it provides additional support for the notion that behavioural engagement is a significant and reliable predictor of achievement.

Therefore, when examining the relationship between academic engagement and achievement, it is important to consider the role of behavioural engagement as it appears to be more closely connected to achievement. These findings demonstrate that positive engagement, specifically behavioural engagement, in high school students plays an important role in their academic achievement. Therefore, this may suggest that promoting the skills of students in the areas of planning, persistence, and task management may contribute to improvements in

achievement. Therefore, future research should aim to develop and measure the efficacy of interventions designed to improve positive engagement in high school students.

Positive Motivation. In contrast to expectations, positive motivation was not found to be a significant predictor of achievement. These findings are incongruent with the majority of the literature, which has typically shown that positive motivation predicts academic achievement (Abdelrahman, 2020; Huang, 2012; Kriegbaum et al., 2015; Steinmayr et al., 2019). Although the lack of significance reported by the current study contradicts what has been demonstrated in the literature, there are some statistical factors that may explain why these results were found. Importantly, although motivation and engagement are distinct from one another, they are still closely related factors (Martin et al., 2017). Motivation constitutes the inner psychological factors within students that reflect their inclination, desire, and drive to learn and achieve in school (Martin, 2007). In contrast, engagement refers to the behaviours that stem from this inclination, desire, and drive (Martin, 2007). Therefore, although the two factors differ, they are also necessarily intertwined. This means that when using both factors within a regression analysis, motivation and engagement will have some degree of shared variance. Importantly, when using multiple regression analyses, the same variance will not be accounted for twice (Tabachnick & Fidell, 2019). This means that when attempting to predict an outcome variable, all of the variance that is shared between factors will only be attributed to one of those factors, and, consequently, will be removed from the others (Tabachnick & Fidell, 2019). In the context of the current study, the shared variance between positive motivation and engagement may have been accounted for in positive engagement and removed from positive motivation, thus explaining the inability for positive motivation to predict academic achievement despite a

relatively large correlation. Therefore, these results may not accurately reflect the role of motivation in predicting achievement and these findings should be interpreted with caution.

Although the relationship between positive motivation and academic achievement may be underrepresented in this study, these results still provide some useful information. For example, these findings suggest that the role of positive engagement in the achievement of high school students may be of greater significance than the role of positive motivation. This is likely because, although the beliefs and attitudes that students hold regarding academics are important, they will not manifest into good grades unless students take actionable steps in their schoolwork. Therefore, this may suggest that academic interventions that first target positive engagement factors will be more effective for promoting achievement, as these factors are more closely linked (Martin et al., 2017).

Negative Motivation and Engagement. Contrary to the hypothesis, neither negative motivation nor negative engagement predicted academic achievement in high school students. Previous research in this area has yielded mixed results; therefore, there are several reasons why these findings may have occurred (Collie, Holliman, et al., 2016; Collie et al., 2017; Huang, 2012; Martin et al., 2021). One possible explanation comes from differences between the samples used in the studies. For example, the relationships between academic achievement and negative motivation and engagement have been shown to differ depending on the ethnic and cultural characteristics of the participants (Martin et al., 2021). Therefore, considering that the sample used in the current study consisted largely of culturally, ethnically, and linguistically diverse participants, the current findings suggest that negative motivation and engagement may have a lesser impact on diverse populations of high school students. This notion aligns with previous research that has demonstrated that the adverse impacts of negative motivation and

engagement are smaller for Indigenous students than for non-Indigenous students (Martin et al., 2021). Although the current study did not use a sample of Indigenous students, these findings may be similar as the samples used in both studies do not come from a western, educated, industrialized, rich, and democratic population (WEIRD; Henrich et al., 2010).

Another reason for these findings may stem from the age of students. Specifically, some of the studies that have shown that negative motivation and engagement negatively predict achievement have used samples of undergraduate university students (Collie, Holliman, et al., 2016; Collie et al., 2017). This may suggest that there are underlying differences between university and high school students, or that self-regulated learning may be more crucial for university, as students have more independence and responsibility (Jacobson et al., 2011; Langberg et al., 2013). Considering that motivation and engagement are essential aspects of self-regulated learning, higher levels of negative motivation and engagement may hinder academic achievement to a greater extent (Zimmerman, 2002).

However, although the relationship between positive motivation, engagement, and achievement has typically been shown to be quite strong, the relationship between negative motivation, engagement, and achievement is reported to be weaker and at times non-significant (Huang, 2012; Martin, 2007; Martin et al., 2021). Thus, the role of negative motivation and engagement is far less clear than the role of positive motivation and engagement. This may be due to bidirectional effects from factors within this category, where variables such as anxiety and failure avoidance may both hinder and promote academic achievement in students. For example, in some situations, students may be motivated to complete their schoolwork to reduce their feelings of anxiety, whereas in other situations, students may avoid doing their schoolwork due to the anxiety that it causes. Therefore, considering that research in this area has yielded mixed

results, there is a need to continue exploring the relationship between negative motivation, engagement, and academic achievement, especially in diverse populations. Additionally, future research should explore how and why the effects of the negative motivation and engagement factors differ.

Motivation, Engagement, and Academic Achievement

Overall, these findings demonstrate that positive engagement plays a large role in predicting the academic achievement of high school students. This suggests that planning, persistence, and task management are central factors related to learning and achievement. Engagement is a crucial component of self-regulated learning, and thus, these findings align with the notion that self-regulated learning is an essential aspect of academic success in high school. Although positive motivation was not identified as a predictor of achievement, the importance of positive motivation should not be overlooked as it is still likely to be strongly implicated in the academic achievement of high school students. Finally, although negative motivation and engagement do not appear to significantly influence the achievement of high school students within this sample, this relationship is less clear. All together, these findings suggest that the positive engagement of high school students should be a priority and that there is a need to further explore the roles of positive motivation, and negative motivation and engagement in high school students, especially within diverse populations.

Implications

Implications for Research

Currently, little research has examined the relationship between EF and academic achievement in high school students (Jacob & Parkinson, 2015). The present study has begun to

fill this gap, by demonstrating that self-reported working memory and metacognition skills are predictive of academic achievement in high school students. Furthermore, this study has shown that other components of EF such as planning, task initiation, flexibility, sustained attention, emotional regulation, response inhibition, organization, time management, and goal-directed persistence do not predict academic achievement in high school students. Therefore, in light of the importance of working memory and metacognition, there is a need to continue exploring how interventions and accommodations can support the development and implementation of working memory and metacognition skills in high school students and in younger students progressing toward high school (Dignath & Buttner, 2008; Duckworth et al., 2013). Furthermore, it will be important to further examine and compare the effectiveness of working memory and metacognition interventions, and assess how well these changes transfer into improved academic achievement. This will enable educators and practitioners to have a better understanding of which interventions will be most helpful in supporting their students to achieve at their highest possible level. For example, a study comparing two metacognitive interventions (e.g., saliency feedback and mental contrasting and implementation intention) may provide useful information pertaining to which intervention is most effective for different age groups (Duckworth et al., 2011; Saenz et al., 2018). These findings will enable students to receive more effective and reliable support for their academic challenges. However, considering that this study is one of few that have explored EF and achievement in high school students, there is a need for future researchers to replicate the current study so that these claims may be confirmed or refuted. This research will hopefully promote others to further explore the implications of EF for high school students.

For academic motivation and engagement, the current findings suggest that high school students with higher levels of positive engagement achieve at a higher level. This may suggest that improving positive engagement in students will also lead to greater achievement. Thus, there is a need to further explore the effectiveness of interventions designed to promote positive engagement in students, and for research that examines how these interventions impact academic achievement in high school students (Collie, Holliman, et al., 2016; Martin & Liem, 2010). Additionally, it will be important for future research to compare the efficacy of different interventions designed to promote positive engagement in students. For example, comparing the effectiveness of academic personal bests interventions and student enrichment programs will allow researchers to better understand which interventions are most helpful for students. This will be beneficial because schools and practitioners will be able to identify and provide more effective supports for students. Furthermore, although positive motivation was not a significant predictor of achievement in this study, it is likely still an important factor related to achievement. Fortunately, motivation and engagement impact one another in circular fashion (Martin et al., 2017). This means that improvements to either of the two should lead to improvements in the other, and that interventions designed to promote positive engagement should also have an adaptive impact on positive motivation. Therefore, these findings suggest that it may be more beneficial to first target interventions designed to promote positive engagement, as this will likely have the largest impact on achievement and will simultaneously promote motivation as well. However, it may still be beneficial to explore the effectiveness of interventions designed to promote positive motivation, and to assess whether these improvements transfer to improvements in academic achievement.

Implications for Schooling

In the educational context, students should be provided with opportunities to excel in a variety of domains, including academics. Findings from the current study show that students' working memory and metacognition abilities are more strongly related to achievement than other EFs. This suggests that schools should prioritize assessing, supporting, and accommodating these factors. Strategies that accommodate for deficits in working memory (e.g., visual aids, breaking down tasks, and providing copies of lecture notes) may provide a more useful long-term approach as they can help to mitigate challenges that are linked with working memory problems (Gathercole et al., 2008). Therefore, in relation to the existing literature, the current findings suggest that supporting students' working memory challenges should be a priority in schools. Furthermore, the findings from the current study suggest that schools should support and foster the metacognitive skills of their students. Importantly, many studies have examined the effects of using metacognitive interventions on students and have found that a variety of interventions can successfully improve metacognition (Dignath & Buttner, 2008; Duckworth et al., 2013; Saenz et al., 2018). Critically, there is also evidence that these improvements are linked to improvements in academic achievement (Duckworth et al., 2013). This suggests that school personnel should use interventions and strategies to promote metacognition in students as this should consequently promote achievement.

Concerning academic motivation and engagement, these findings suggest that that it might be beneficial for schools to be mindful about fostering positive engagement in students as this may promote academic achievement. Specifically, school personnel may be able to support students' abilities to persist, plan, and manage tasks by considering relational or environmental modification, or even through specific interventions (Collie, Martin, et al., 2016; Martin, 2006;

Martin et al., 2017). Additionally, schools should also consider the role of positive motivation as it is likely still closely related to achievement. Therefore, it may be beneficial for schools to implement strategies to promote self-efficacy, valuing, and mastery orientation as these factors are linked with greater achievement. Lastly, if schools are able to implement strategies to promote engagement and motivation, it may be more effective to focus their resources on promoting positive motivation and engagement factors rather than reducing negative motivation and engagement factors. This is because the research connecting the negative factors with lower academic achievement has produced mixed results, suggesting that it is less clear how disengagement, self-handicapping, failure avoidance, anxiety, and uncertain control impact academic achievement.

In the context of school psychology, these finding suggest that there are several strategies that may improve outcomes for high school students. First, considering the importance of working memory and metacognition for academic achievement, it may be beneficial to include the assessment of these skills when implementing a Response to Intervention (RTI) model. Although further research should be conducted to confirm the findings from the current study, the addition of working memory and metacognition assessment will likely provide useful information to educators and practitioners. For example, this strategy will help to identify students with deficits in working memory and metacognition and will enable educators to provide specific supports and interventions to these students as a way to promote their academic success. Additionally, the findings from the current study suggest that including positive motivation and engagement assessment in RTI models may also provide meaningful benefits to students. Specifically, this model should focus on examining positive motivation and engagement in students, as these factors are most relevant to academic achievement. By using

this strategy, students with lower levels of positive motivation and engagement will be identified and may be able to access support services that will promote their academic achievement, and thus, a variety of adaptive outcomes.

Strengths and Limitations

One limitation of this study is that it does not control for prior achievement or intelligence. These variables have been consistently identified as some of the best predictors of academic achievement in students across all groups (Hailikari et al., 2007; Kuncel et al., 2004). The reason that this study did not control for these variables is that the time and/or financial costs would be extremely high, placing higher demands on the school staff, and exceeding the budget for the study. Furthermore, the data was collected from a larger study which focussed on the impact of educational neuroscience. Considering that two important controls were not included in this study, the variance accounted for by the significant variables is likely somewhat inflated.

Another limitation of this study is that it used a cross-sectional design. This means that the information gathered from this research only looks at how the factors relate to one another at a single time-point. Therefore, none of the findings can be interpreted as causal. Although this study used data from a larger study which re-assessed students at multiple time points across the school year, the researchers relied on the school staff to submit students' grades throughout the school year. Unfortunately, there were not enough participants whose grades were submitted after the first data collection phase, so only the data from the initial collection phase was used in this analysis. If the current study had received data regarding student grades at multiple time points throughout the school year, we would have been able to better understand the relationships between academic achievement, EF, and motivation and engagement in high school students.

Furthermore, this study only used GPA to measure academic achievement. There are a few reasons why this is a limitation. First, this may have resulted in inconsistent scores for achievement, as the grades students receive are not standardized. Instead, teachers grade students somewhat subjectively, which means that there are likely differences between how each teacher grades their students. Second, no differentiation was made between the class level. For example, if a student was taking an advanced mathematics course, their grades in that class would count the same as a student in a less challenging stream. Lastly, the number of classes that students were taking in one semester was not accounted for. For example, some students took on heavier course loads (e.g., four core subjects), whereas other students took on lighter course loads (e.g., two core subjects). Regardless of the number of subjects taken within a semester, students' GPAs were calculated by averaging their grades across all of their core subjects in one semester. Thus, students' GPA scores may not account for all relevant factors and, consequently, may not accurately reflect their achievement. Another limitation of this study comes from the EF measure used. This version of the measure was not validated and only used three items to assess each executive skill. This may have resulted in EF scores that were not representative of student functioning, or that were not comprehensive representations of each executive skill.

Finally, COVID-19 had a large impact on this research, as data was being collected throughout this period. The pandemic caused schools to substantially alter their operations, policies, and teaching methods. These changes undoubtedly affected students as they were forced to adapt to constantly changing and uncertain environments. This likely impacted students' grades, mental health, and stress levels which may have also affected their EF and motivation and engagement toward school. Therefore, the current findings should be considered in the context of COVID-19 and may not generalize to students attending school outside of the

pandemic. Furthermore, the policies put in place in schools meant that the researchers were unable to enter the schools to assist with the data collection procedure and answer any questions that may have arisen. Additionally, typical translational services were not able to be provided due to the unexpected demands of COVID-19 on the school district. This may have affected recruitment by limiting the number of participants who engaged in the study, as some individuals may have had difficulties with the English language and were unable to receive interpretive support. This likely resulted in lower participation in the study. Despite the difficulties that COVID-19 caused, we were fortunate to have been able to conduct the study and are appreciative of the willingness and cooperation of the schools, students, and staff.

In addition to limitations, this study also had a number of strengths. Firstly, there is a lack of research that examines culturally and ethnically diverse population. Instead, the majority of research is conducted in WIERD populations (Henrich et al., 2010). The current study used a diverse sample drawn from schools containing a wide range of multi-cultural students consisting of students who identified as Asian (61%), Black or African (10%), White (10%), Hispanic/Latino (7%), Mixed Race (7%), Indigenous/Metis (1%), Pacific Islander (1%). Therefore, one strength of this study is that it has begun to address the issue of a lack of diversity in participant groups by incorporating diverse populations into the research. Additionally, this study begins to address a gap in the literature pertaining to the relationship between academic achievement, EF, and motivation and engagement in high school students. Finally, the measurement tools used in this study for assessing motivation, engagement, and EF in students are accessible and cost-efficient. Therefore, these findings may be applied directly in schools, as educators can acquire these tools, measure these constructs, and interpret the results with relative ease.

Conclusion

In conclusion, this study explored the relationships between academic achievement, EF, and motivation and engagement in a diverse high school sample. Regarding EF, the findings suggest that working memory and metacognition play the largest role in predicting academic achievement in high school students. However, there is still uncertainty regarding the relationship between achievement and the other components of EF. This means that there is a need for further research in this area. As for motivation and engagement, this study demonstrates that positive engagement is an important predictor of academic achievement. Although positive motivation was not identified as a predictor of achievement, the relationship between motivation and engagement is strong, and the role of positive motivation is still believed to be important. On the other hand, the role of negative motivation and engagement is less clear, and there is a need for continued research in this area. This study has provided further clarification of the roles of EF, motivation, and engagement in predicting academic achievement in high school students.

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Appendix A

Certification of Institutional Ethics Review

Conjoint Faculties Research Ethics Board
Research Services Office
2500 University Drive, NW
Calgary AB T2N 1N4
Telephone: (403) 220-4283/6289
cfreb@ucalgary.ca

CERTIFICATION OF INSTITUTIONAL ETHICS REVIEW

The Conjoint Faculties Research Ethics Board (CFREB), University of Calgary has reviewed and approved the below research. The CFREB is constituted and operates in accordance with the current version of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS).

Ethics ID:	REB21-0329
Principal Investigator:	Gabrielle Wilcox
Co-Investigator(s):	
Student Co-Investigator(s):	Ryan Clancy
Study Title:	Executive Function, Motivation and Engagement: Impact on Academic Achievement
Sponsor:	University of Calgary

Effective: 31-May-2021 **Expires:** 31-May-2022

Restrictions:

This Certification is subject to the following conditions:

1. Approval is granted only for the research and purposes described in the application.
2. Any modification to the approved research must be submitted to the CFREB for approval.
3. An annual application for renewal of ethics certification must be submitted and approved by the above expiry date.
4. A closure request must be sent to the CFREB when the research is complete or terminated.

Approval by the REB does not necessarily constitute authorization to initiate the conduct of this research. The Principal Investigator is responsible for ensuring required approvals from other involved organizations (e.g., Alberta Health Services, community organizations, school boards) are obtained.

Approved By:	**Date:**
Jenny Godley, PhD, Chair , CFREB	31-May-2021

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix B

Executive Skills Questionnaire-Teen Version

Executive Skills Questionnaire-Teen Version

Rate each item below based on how well it describes you, using this rating scale to choose the appropriate scored. Then add the three scores in each section. Use the key on the next page to determine your executive skills strengths (two to three lowest scores) and weaknesses (two to three highest scores).

1	2	3	4	5	6	7
Strongly disagree	Disagree	Tend to disagree	Neutral	Tend to agree	Agree	Strongly agree

Item	Score
1. I act on impulse	
2. I get in trouble for talking too much in class.	
3. I say things without thinking.	
TOTAL SCORE:	
4. I say, "I'll do it later" and then forget about it.	
5. I forgot homework assignments or forget to take home needed materials.	
6. I lose or misplace belongings such as coats, gloves, sports equipment, etc.	
TOTAL SCORE:	
7. I get annoyed when homework is too hard or confusing or takes too long to finish.	
8. I have a short fuse-am easily frustrated.	
9. I get upset when things don't go as planned.	
TOTAL SCORE:	
10. If the first solution to a problem doesn't work, I have trouble thinking of a different one.	
11. I get upset when I have to change plans or routines.	
12. I have problems with open-ended homework assignments (e.g., deciding what to write about when given a creative writing assignment).	
TOTAL SCORE:	
13. I have difficulty paying attention and am easily distracted.	
14. I run out of steam before finishing homework or other tasks.	
15. I have problems sticking with schoolwork or chores until they are done.	
TOTAL SCORE:	
16. I put off homework or chores until the last minute.	
17. I have difficulty setting aside fun activities in order to start homework.	
18. I need to be reminded to start chores or homework.	
TOTAL SCORE:	

Executive Skills Questionnaire-Teen Version (cont.)

19. I have trouble planning for big assignments (knowing what to do first, second, etc.). _____
20. I have difficulty setting priorities when I have a lot of things to do. _____
21. I become overwhelmed by long-term projects or big assignments. _____

TOTAL SCORE: _____

22. My backpack and notebooks aren't organized. _____
23. My desk or workspace at home or school is a mess. _____
24. I have trouble keeping my bedroom or locker tidy. _____

TOTAL SCORE: _____

25. I have a hard time estimating how long it takes to do something (such as homework). _____
26. I often don't finish homework at night and may rush to get it done in school before class. _____
27. I need a lot of time to get ready for things (e.g., appointments, schools, changing classes. _____

TOTAL SCORE: _____

28. I can't seem to save up money for a designed object-problems delaying gratification. _____
29. I don't see the point of earning good grades to achieve a long-term goal. _____
30. I prefer to live in the present. _____

TOTAL SCORE: _____

31. I don't have very effective study strategies. _____
32. I tend not to check my work for mistakes even when the stakes are high. _____
33. I don't evaluate my performance and change tactics to increase success. _____

TOTAL SCORE: _____

KEY

Items	Executive skill	Items	Executive skill	Items	Executive skill
1-3	Response inhibition	13-15	Sustained attention	25-27	Time management
4-6	Working memory	16-18	Task initiation	28-30	Goal-directed
7-9	Emotional control	19-21	Planning/prioritizing		Persistence
10-12	Flexibility	22-24	Organization	31-33	Metacognition