THE UNDERACHIEVEMENT AND PERFORMANCE OF HIGH SCHOOL STUDENTS WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

by
Brent Ashley Jones

A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of Education

Baltimore, Maryland
July 2019

© 2019 Brent Ashley Jones
All rights reserved
Abstract

High school students with Attention-Deficit/Hyperactivity Disorder (ADHD) demonstrate significant academic underachievement and poor educational performance (Barkley, 1997; Loe & Feldman, 2007). The first chapter of the following research study explores the roots of this problem from a cognitive theoretical perspective and disputes many of the common approaches to remediating the problem via behavioral interventions. Chapter 2, the needs assessment study, confirmed the research at a suburban middle-class high school. Students in the sample with ADHD significantly underachieved, underperformed, were given a high percentage of accommodations that were not evidence-based, and demonstrated evidence of working memory deficits. The literature review in Chapter 3 examines interventions aimed at improving the cognitive deficits of high school student with ADHD. It utilized the information processing system as the theoretical framework and examined three separate approaches for helping students with WM deficits: (1) Cogmed Working Memory Training, (2) mindfulness training, and (3) cognitive load reduction strategies. I examined each approach for student compliance, ability to influence near transfer and far transfer effects, and overall demonstration of effectiveness on academic performance and achievement of high school students with ADHD. Chapter 4 outlines a proposed single-subject multiple baseline mixed-methods study of an intervention aimed at improving the academic performance of high school students with ADHD. Finally, Chapter 5 discusses the results of the study which found that the Cognitive Load Reduction Program provided a differential boost that prevented a regression in academic performance observed in students with ADHD who did not complete the program.

Dissertation Advisor: Christine Eccles

Secondary Readers: Carey Borkoski and Mary Ellen Lewis
Dedication

This dissertation is dedicated to my family:

To my parents, Kerry Stephen Jones and Valerie Joan Jones, who always encourage me to explore the world and my talents,

To my sons, Charles Stephen Jones II and Theodore D’Arcty Jones, for their patience, understanding, love, and support throughout this process,

And finally, to my wife, Mary Charlotte Doherty Jones, who believed in me and what I could accomplish even when I did not believe it myself.
Acknowledgements

This dissertation would not have been possible without the support and guidance of several individuals, to all of whom I am eternally grateful.

I appreciate the time and contributions of my doctoral committee towards my growth as a research practitioner. To my advisor, Dr. Christine Eccles, I am thankful that she pushed me to think critically, keep an open mind, improve my writing, and that she helped me view educational research as a never ending process towards incremental improvements. Her wisdom and experiences were invaluable. I am also grateful to my other two committee members: Dr. Carey Borkoski and Dr. Mary Ellen Lewis. Dr. Borkoski was a constant source of encouragement and empowerment mixed with constructive, timely, and necessary feedback. Dr. Lewis’ expertise in the public school system and intimate knowledge of special education helped me utilize research as a change agent.

This research was not possible without the support and assistance of several key administrators and faculty in the school district. I am grateful to Superintendent Dr. Jim Scanlon, who granted access, gave his time, and for his willingness to help me achieve my goals. I am also thankful to the Director of Pupil Services, Dr. Leigh Ann Ranieri, who helped me devise an intervention, recruit participants, and collect data. Additionally, I could not have completed the study without the help of the following teachers: Kim Phillips, Courtney Zimmerman, Christine Faslis, Sarah Shapard, Shanelle Dorsey, and Erin Stephen.

Finally, I am thankful to my friends in the educational doctorate program. When Allison Gubanich Williams, Juliana Ospina Cano, Carole Arrington-English, and I sat down together during orientation we did not yet know that it would be the most important event of our journey through the Johns Hopkins University. The collective resolve, humor, and intellect of the group
helped me through the program, and I would not have survived the marathon writing sessions, synchronous sessions, and a maze of deadlines and directions without them. A special thanks belongs to Alli for her assistance with my research at a time when she could have been doing other things for herself and her family. I am grateful that all three of them sat with me during orientation before year one and, that they stayed by my side throughout the next three years.
# Table of Contents

Abstract ........................................................................................................................................... ii
Dedication ........................................................................................................................................ iii
Acknowledgements ....................................................................................................................... iv
List of Tables ..................................................................................................................................... x
List of Figures ................................................................................................................................... xi
Executive Summary ....................................................................................................................... 1
  Schools Focus on Behavior and Often Ignore Cognitive Factors .................................................. 1
  Needs Assessment at Nest View High School ............................................................................... 2
  Cognitive Load Reduction for Working Memory Deficits ............................................................. 3
  Interventions Aimed at WM Deficits ............................................................................................. 3
  A Single-Subject Mixed Methods Research Design ..................................................................... 4
  Findings .......................................................................................................................................... 6
Chapter 1 .......................................................................................................................................... 7
  Statement of the Problem ............................................................................................................. 7
    Theoretical Framework- The Cognitive Perspective ................................................................. 9
    Organization and Conceptual Framework ............................................................................... 10
Literature Review .......................................................................................................................... 12
  ADHD is Viewed as a Behavioral Problem ............................................................................... 12
  Executive Function and ADHD .................................................................................................. 13
    Theories of executive function in ADHD ................................................................................ 13
    ADHD and studies of the extent of executive function deficits ............................................. 14
    Executive function deficits and math ....................................................................................... 15
    Executive function deficits and reading ................................................................................... 16
    Working memory .................................................................................................................... 17
    Working memory and attention ............................................................................................... 18
  ADHD Comorbidity ..................................................................................................................... 21
    ADHD and learning disabilities ............................................................................................... 21
    ADHD and reading disabilities ............................................................................................... 21
  Special Education ........................................................................................................................ 22
    History of the laws ................................................................................................................... 22
    Accommodations for ADHD lack efficacy ............................................................................. 23
The extended time accommodation ................................................................. 24
Parents’ inability to effectively influence the IEP process................................. 26

Teachers ........................................................................................................... 27
Knowledge......................................................................................................... 27
Relationships. ................................................................................................. 28
Training and education. ................................................................................... 29

Conclusion ....................................................................................................... 31

Chapter 2 ......................................................................................................... 34

Introduction to the Problem of Practice in Context ......................................... 34

Goals and Objectives ...................................................................................... 36

Methodology ................................................................................................... 37
Participants. ..................................................................................................... 37
Measures. ......................................................................................................... 39

Data Collection Methods ............................................................................... 43

Initial Summary of Results ............................................................................. 44
Pennsylvania Keystone Exam scores as measures of academic achievement...... 44
Grade point average and class rank as measures of academic performance. ... 44
Identification of working memory deficits ...................................................... 45
Accommodations for students with ADHD ...................................................... 45

Discussion ....................................................................................................... 47

Limitations ....................................................................................................... 48

Moving Forward ............................................................................................... 49

Chapter 3 ......................................................................................................... 50

Working Memory Deficits and the Academic Achievement of Students with ADHD..... 50

Theoretical Framework - The Information Processing System and Working Memory .. 51

Two Intervention Approaches for Working Memory Deficits ......................... 53

Literature Review of Interventions ................................................................. 55
Cogmed Working Memory Training (CWMT) ................................................. 55
Mindfulness training....................................................................................... 63
Cognitive load reduction ................................................................................ 67

Conclusions ..................................................................................................... 71

Chapter 4 ......................................................................................................... 74
Purpose of the Study ........................................................................................................... 74
Research Design .................................................................................................................. 75
Logic Model ........................................................................................................................ 77
Process Evaluation ............................................................................................................. 79
  Context .............................................................................................................................. 80
  Fidelity of implementation: Participant responsiveness ....................................................... 80
  Fidelity of dose .................................................................................................................. 81
Outcome Evaluation ............................................................................................................ 81
  Threats to internal validity ............................................................................................... 82
  Threats to external validity .............................................................................................. 83
Methods ............................................................................................................................. 83
  Participants ....................................................................................................................... 83
  Instruments and materials ............................................................................................ 86
Procedure ............................................................................................................................ 89
  Participant recruitment .................................................................................................... 89
  Intervention ................................................................................................................... 89
  Data collection ................................................................................................................ 91
  Data management ......................................................................................................... 92
  Data analysis .................................................................................................................. 92
  Mixed methods connected data analysis ....................................................................... 95
Summary Matrices .............................................................................................................. 95
Chapter 5 .......................................................................................................................... 98
Organizational Framework and Research Questions ......................................................... 99
Fidelity of Implementation ................................................................................................. 100
  Participant responsiveness .............................................................................................. 100
  Intervention dose ........................................................................................................... 102
Impact of the CLRP on Academic Performance ............................................................... 103
  Trend ............................................................................................................................... 109
  The immediacy of the effects ......................................................................................... 110
Participants’ Perceptions of the CLRP ............................................................................ 111
Quantitative and Qualitative Data Merge ......................................................................... 112
  Experimental effect and non-responders ..................................................................... 114
# Table of Contents

A Differential Boost ........................................................................................................ 115

**Threats to External Validity** ......................................................................................... 116

**Challenges of Special Education Research** ................................................................. 117

- The importance of the special education teachers .......................................................... 117
- The legal rights of the parents and students .................................................................. 118
- Power and coercion ....................................................................................................... 119
- Mediating variables ....................................................................................................... 119

**Conclusions** ................................................................................................................. 119

References .......................................................................................................................... 122

Appendix A ......................................................................................................................... 139

Interview with a School Guidance Counselor ................................................................ 139

Appendix B .......................................................................................................................... 143

Interview with a School Special Education Teacher ....................................................... 143

Appendix C .......................................................................................................................... 146

Interview Notes with a School Psychologist ................................................................. 146

Appendix D .......................................................................................................................... 149

Cover Letter for the Needs Assessment Study ............................................................... 149

Appendix E .......................................................................................................................... 151

Student Assent and Parental Informed Consent for the Needs Assessment Study ...... 151

Appendix F .......................................................................................................................... 155

Worked Examples Practice Lesson .............................................................................. 155

Appendix G .......................................................................................................................... 156

Memory Aid of CLRP ...................................................................................................... 156

Appendix H .......................................................................................................................... 157

Participant Recruitment Cover Letter ........................................................................... 157

Appendix I .......................................................................................................................... 159

Assent Form for the Intervention Study .......................................................................... 159

Appendix J .......................................................................................................................... 159

Interview Questions ......................................................................................................... 159
List of Tables

Table 1  
*Needs Assessment Research Questions* ..........................................................37

Table 2  
*Grading System* .................................................................41

Table 3  
*Coded Accommodations According to Spiel, Evans, and Langberg (2013)* ..........42

Table 4  
*Pennsylvania Keystone Exam Scores* .........................................................44

Table 5  
*Accommodations from sampled students’ IEP coded according to Spiel et al. (2013)*........47

Table 6  
*Compliance Rates of CWMT* .................................................................56

Table 7  
*Grading System* .................................................................81

Table 8  
*Participants Working Memory Scores* .........................................................85

Table 9  
*RQ1: To what extent are high school students with ADHD completing the Cognitive Load Reduction Worked Examples intervention activities and utilizing the strategy as intended during testing?* .........................................................95

Table 10  
*RQ2: Does learning a cognitive load reduction strategy from worked examples and employing the use of a memory aid of the strategy during testing lead to the increased academic performance of high school students with ADHD?* .........................................................96

Table 11  
*RQ3: What are ADHD high school student perceptions of the impact of extrinsic cognitive load on test performance?*  
*RQ4: How do ADHD students believe the CLRP impacted cognitive load during testing and in the classroom?* .................................................................96

Table 12  
*RQ5: To what extent does the ADHD student perceptions confirm the test score data?*  

Table 13  
*Intervention Schedule* .................................................................100

Table 14  
*Fidelity of Implementation* .................................................................101

Table 15  
*Test and Quiz Score Averages for Each Phase of the Study* ......................................107

Table 16  
*Immediacy of Effects* .................................................................111

Table 17  
*Joint Display of Quantitative and Qualitative Data* .............................................113
List of Figures

Figure 1
    Information processing model of learning and memory ........................................10
Figure 2
    Conceptual Framework .........................................................................................11
Figure 3
    Recreation of Alan Baddeley’s (2012) WM Model ..................................................52
Figure 4
    Logic Model of an ADHD Intervention .................................................................77
Figure 5
    Example of a Multiple Baseline Single-Subject Research Design Visual ...............93
Figure 6
    Systematic Visual Comparison of the Effects of a CLRP on Test and Quiz Performance…104
Figure 7
    Pre and Post Intervention Test and Quiz Scores ....................................................108
Figure 8
    The change in the trend of Test and Quiz Scores for Participants 2 and 5 ..............109
Executive Summary

According to the Centers for Disease and Prevention Control, nearly 11% of children ages 4-17 received a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) as of 2011 (Visser et al., 2016). Section 504 of the Rehabilitation Act (1973) and the Individuals with Disabilities Education Act (IDEA, 1975, 2004) requires school districts to provide educational supports and interventions to students with ADHD in the form of 504 plans and Individualized Education Programs (IEP). Despite the laws and additional capital expenditures averaging $20,000 a year per pupil, high school students with ADHD demonstrate significant academic underachievement and poor educational performance (Barkley, 1997; Loe & Feldman, 2007; Pelman, Foster, & Robb, 2007; Robb et al., 2011). They receive lower grades, take fewer advanced courses, fail more often, are rated by teachers as poor performers, have poorer school attendance (which also negatively correlates with academic success), and are more likely to drop out (Kent et al., 2011; Langberg et al., 2011).

Schools Focus on Behavior and Often Ignore Cognitive Factors

Typically, ADHD is treated in schools as a behavioral issue, yet recent neuroimaging suggests that, as compared to non-ADHD students, these students have differences in the structure and function of specific brain regions involved in executive function (England-Kennedy, 2008; Hoogman et al., 2015; Laurence, 2008; Neufeld & Foy, 2006; Makris et al., 2015). Accommodations should address these key differences. However, evidence suggests that many of the typically implemented accommodations in IEP and 504 plans for ADHD, such as extended time on tests, lack efficacy (Lewandowski, Hendricks, & Gordon, 2012; Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Lovett & Leja, 2015; Murray et al., 2014; Pariseau et al., 2010; Pritchard et al., 2016; Spiel, Evans, & Langberg, 2014). Parents are often ill-equipped
to effectively contribute to the IEP and rely on classroom and special education teachers’ expertise (DeRoche, 2015; Trainor, 2010; Wiener & Daniels, 2016). Many teachers, however, lack the knowledge and training to help students with ADHD (Bussing et al., 2001; Guerra & Brown, 2015; Jones & Chronis-Tuscano, 2008; Rush & Harrison, 2008; Weyandt, Fulton, Schepman, Verdi, & Wilson, 2009). Thus, IEPs teams often construct the accommodations for ADHD students based on overt behavioral issues and ignore the covert cognitive deficits.

While many educators focus on inattentive behaviors such as lack of eye contact and hyperactive behaviors such as excess fidgeting, they often fail to recognize that the academic problems for ADHD students may stem from cognitive deficits in the information processing system (Biederman et al., 2004; Kofler et al., 2014; Lambek et al., 2011; Mattfeld et al., 2016; Schreiber, Possin, Girard, & Rey-Casserly, 2014; van Lieshout et al., 2016). Students with ADHD have working memory (WM) deficits (Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Mattfeld et al., 2016; Wilcutt et al., 2005). An updated version of the original model by Baddeley and Hitch (1974) defines WM as the storage, rehearsal, processing, maintenance, and manipulation of temporarily held phonological and visuospatial information (Baddeley, 2003). Students with ADHD often have WM deficits which impairs their ability to read, solve math problems, and predicts lower overall academic achievement (Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Mattfeld et al., 2016; Wilcutt et al., 2005).

Needs Assessment at Nest View High School

The findings of a needs assessment study conducted in the spring of 2017 at Nest View, a large suburban high school in Pennsylvania, were consistent with previous research and indicated that high school students with ADHD significantly underachieved, underperformed,
and had accommodations in IEP that lacked evidence of efficacy. Further, the students scored low on measures of working memory or were not tested for it. The context for the current study exists in three spaces within three high schools in the Nest View School District: the specialized instruction classroom, the testing room, and Schoology (the online course management system online instruction and assessment.

**Cognitive Load Reduction for Working Memory Deficits**

According to the framework established by Sweller, van Merrienboer, and Paas (1998), there are two ways to help students with deficits in WM. The first is to make attentional processes automatic through routinizing and repetition of the skill, thereby limiting the intrinsic cognitive load. The second approach is to present tasks in a way that minimizes the amount of stress placed on WM, which reduces the extrinsic cognitive load.

**Interventions Aimed at WM Deficits**

Cogmed Working Memory Training (CWMT) by Pearson Education, Inc. is one of the most extensively studied programs aimed at improving students WM via computerized repetitive skill development (Kirk, Gray, Riby, & Cornish, 2015). Studies on the impact of CWMT on ADHD symptoms, academic performance, and achievement report conflicting results and, the most rigorous studies with large sample sizes and adequate controls demonstrated no significant impact (Beck et al., 2010; Bigorra et al., 2015; Chacko et al., 2014; Dahlin, 2011; Gray et al., 2012; Hitchcock & Westwell, 2017; Soderqvist & Nutley, 2015; van der Donk et al., 2015). Another recent approach studied because of its connection to executive functions, including WM, is mindfulness training (Buttle, 2011). Results from mindfulness training are similar to those of CWMT with some evidence of near transfer to measures of WM, but little evidence suggests improved academic achievement and performance (Quach et al., 2016; van Vugt & Jha,
Cognitive load reduction strategies are a viable alternative as they may improve academic success for students with WM deficits and low-knowledge learners (Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). Cognitive load reduction is defined as any process that reduces the number of elements of information demanded of working memory (Sweller, 2016). For example, a test may have three or four directions that students have to remember while also accessing their long-term memory for an answer and blocking out distracters. A student could cross out the distracters to lessen the amount of information processed in WM.

**A Single-Subject Mixed Methods Research Design**

The current study utilized a single-subject multiple-baseline mixed methods embedded research design (QUAN > qual). There are typically three to eight participants in a study with each one serving as their own control with baseline measurements of the dependent variable before the intervention. The population of the present study was four high school students (grades 9-12) in the three high schools at Nest View School District with an IEP that lists “Other Health Impairment” as their primary or secondary disability.

The typical independent variable in a single-subject design is an intervention, which in the current study was a cognitive load reduction program (CLRP). The intervention combined three separate strategies aimed at reducing the cognitive load for ADHD students: (1) learning testing strategies to manage the amount of information in test instructions and test questions, (2) studying the strategy through the use of worked examples, and (3) utilizing a memory aid of the strategy while using the extended time testing accommodation. Recently, Nest View School District adopted an executive functions curriculum framework for the study skills classes taught to students with an IEP. The curriculum follows the *Executive Functions: A Blueprint for
Success guidebook by the Rush NeuroBehavioral Center (Bozeday, Gidaspow, & Allen, 2016). The fourth unit, Study Strategies, includes a worksheet on how to break down directions (Executive Functions, p. 31). The CLRP builds on the strategies described in the Executive Functions guidebook and demonstrates how students can use the same strategy to break down the components of a test question.

The worked examples in each lesson demonstrated to the students the CLRP which included (1) circling direction words, (2) underlining key words, (3) crossing out distractors, and (4) defining key vocabulary in the margins. Worked examples reduce the extrinsic cognitive load placed on WM and have demonstrated success in mathematical problem solving and helping low knowledge learners (Booth et al., 2015; Cooper & Sweller, 1987; Paas & van Merrienboer, 1994; Sweller & Cooper, 1985). This method requires the student to study a solution to a problem instead of solving the actual problem (Pawley, Ayres, Cooper, & Sweller, 2005). The instructional materials included sample tests directions and questions from students’ ninth-grade core subject classes of language arts, social studies, math, and science.

Remembering how to use the CLRP during a test would require the use of the central executive in WM to access the strategy from long-term memory when applicable which could further stress WM. Newell and Simon (1972) demonstrated that external memory aids reduce the cognitive load on WM. Therefore, the intervention design included teachers in the testing room supplying each participant in the study with a paper copy memory aid of the CLRP strategy for their reference while taking unit tests.

The dependent variable was test and quiz scores in the participants’ core classes for the 30-week study. In addition, qualitative data gathered from structured student interviews...
supplemented the quantitative data by inclusion of descriptions of participant responsiveness, understanding of the CLRP, use of it, and perceived benefit.

**Findings**

The Cognitive Load Reduction Program aimed at improving the academic performance and achievement of high school students with Attention-Deficit/Hyperactivity Disorder demonstrated moderate levels of success with some students. The results suggested that students who learned the strategy through the online lessons and utilized it in their academic coursework did not have a regression in scores throughout the year. Additionally, the data suggests that test and quiz scores of the two students who implemented the cognitive load reduction strategy changed from a negative slope before the intervention to a slightly positive slope after the intervention. Conversely, test and quiz scores of the participants who did not implement the strategy showed a negative slope before the intervention that continued after they learned the strategy and did not implement it. Performance of participants that did not learn or implement the strategy showed a regression in overall grades, test, and quiz scores. The findings from the current study suggest that CLRP for high school students with ADHD may be a possible intervention to provide a needed differential boost for students who often struggle academically.
Chapter 1

Statement of the Problem

According to the Centers for Disease and Prevention Control, nearly 11% of children ages 4-17 received a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) as of 2011 (Visser et al., 2016). Section 504 of the Rehabilitation Act (1973) and the Individuals with Disabilities Education Act (IDEA, 1975) require school districts to provide educational supports and interventions to students with ADHD in the form of Individualized Education Programs (IEP) and 504 plans. Children with ADHD are 3 to 7 times more likely to access special education services than their non-ADHD peers (LeFever, Villers, Morrow, & Vaughn III, 2002). As a result, school districts spend an additional $20,000 per year on every student with ADHD (Pelman, Foster, & Robb, 2007; Robb et al., 2011). Despite the laws and additional capital expenditures, high school students with ADHD demonstrate significant academic underachievement and poor educational performance (Barkley, 1997; Loe & Feldman, 2007). They receive (1) lower grades, (2) take fewer advanced courses, (3) fail more often, (4) are rated by teachers as poor performers, (5) have poorer school attendance (which also negatively correlates with academic success), and (6) are more likely to drop out (Kent et al., 2011; Langberg et al., 2011). Additionally, students with ADHD have lower scores on cognitive tests, intelligence tests, receptive vocabulary, and verbal intelligence (Loe et al., 2008).

ADHD’s rise in American consciousness and its impact on education derived from an incomplete understanding of the disorder as based largely on behavioral symptoms (EnglandKennedy, 2008; Laurence, 2008; Neufeld & Foy, 2006). It was not until recently that a new understanding of the structural differences of the ADHD brain emerged. Makris et al. (2015) conducted the first known MRI of medication-naïve participants who reached adulthood still
displaying symptoms of ADHD. Their results showed volumetric differences in the cerebellum and caudate nucleus of adult ADHD participants relative to the controls. They stated that the structural differences they identified in ADHD participants are key components in attention, executive control, and emotional regulation. Hoogman et al. (2017) confirmed Makris et al. (2015) and added greater validity with the largest ADHD brain imaging study to date (1713 with ADHD and 1529 healthy controls). They concluded that patients with ADHD have structural differences in the accumbens, amygdala, caudate, hippocampus, putamen, and intracranial volume. The recent findings by Makris et al. (2015) and Hoogman et al. (2017) demonstrated that ADHD is a disorder of the brain.

Students with ADHD continue to struggle despite implementation of various accommodations, and a possible explanation is that the accommodations focus on an outdated belief system associated with behavioral symptoms. That many of the typically implemented accommodations for ADHD lack efficacy has been well documented (Lewandowski, Hendricks, & Gordon, 2014; Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Lovett & Leja, 2015; Murray et al., 2014; Spiel, Evans, & Langberg, 2014). The most common accommodation for ADHD, extended time on tests, does not provide a differential boost to students with ADHD or significantly improve performance (Lewandowski et al., 2014, 2007; Lovett & Leja, 2015; Murray et al., 2014; Pariseau et al., 2010; Pritchard et al., 2016).

Parents are often ill-equipped to effectively contribute to the IEP and rely on classroom and special education teachers’ expertise (DeRoche, 2015; Trainor, 2010; Wiener & Daniels, 2016). Yet, most teachers lack the knowledge and training to help students with ADHD (Bussing et al., 2001; Guerra & Brown, 2015; Jones & Chronis-Tuscano, 2008; Rush & Harrison, 2008; Weyandt, Fulton, Schepman, Verdi, & Wilson, 2009). Schunk (2012) explains
that teachers often spot attention by searching for behavioral cues such as eye contact, sitting quietly, and handwriting. The presence of these behaviors, however, does not indicate if a student is cognitively paying attention to the relevant stimuli in a particular learning situation. This mistaken belief about attentive behaviors equaling attentive minds and teachers’ relative lack of knowledge about ADHD help explain many of the ineffective accommodations recommended on an IEP for students with ADHD.

According to the Diagnostic and Statistical Manual 5th Edition (DSM-5), there are two subtypes of ADHD: Inattentive and Hyperactive. While many educators focus on the inattentive behaviors such as lack of eye contact and hyperactive behaviors such as excess fidgeting, they often fail to recognize that the academic problems for ADHD students stem from executive function deficits (EFD) in working memory and inhibition. Recent cognitive research demonstrates that many students with ADHD have EFD’s which are significant contributors to academic underachievement and performance (Biederman et al., 2004; Blair & Razza, 2007; Bull & Scerif, 2001; Gathercole et al., 2016; Kirk, Gray, Riby, & Cornish, 2015; Kofler et al., 2014; Lambek et al., 2011; Mattfeld et al., 2016; Schreiber et al., 2014; Seymour, Mostofsky, & Rosch, 2016). Therefore, the cognitive differences of students with ADHD is central to understanding the significant academic underachievement and poor performance of students with the disorder.

Theoretical Framework - The Cognitive Perspective

The cognitive theoretical perspective focuses on human thought, memory and the processing of information. Among the many concepts within this perspective is the information processing system proposed by Atkinson and Shiffrin (1968). Their model (Figure 1) included information entering the senses, the perception of it, transfer to short-term or working memory,
further processing before the information is stored in long-term memory, and then retrieval. The control (executive) processes the flow of information through this system.

Figure 1

*Information processing model of learning and memory*

![Information processing model of learning and memory](image)


**Organization and Conceptual Framework**

The literature review will follow the conceptual framework illustrated below (Figure 2). The first section of the literature review will examine the historical and cultural roots of the perception that ADHD is a behavioral problem. The consequences of this false perception are explored within a review of the empirical research which explores ADHD as a neurophysiologically-based deficit that is proposed to involve problems with executive function, working memory and/or inhibition (Biederman et al., 2004; Blair & Razza, 2007; Bull & Scerif, 2001; Gathercole et al., 2016; Kirk et al., 2015; Kofler et al., 2014; Lambek et al., 2011; Mattfeld et al., 2016; Schreiber et al., 2014; Seymour et al., 2016). Additionally, ADHD can co-occur with a learning disability or reading disability further complicating the efforts to provide effective accommodations (Barkley, 2014; DuPaul, Gormley, & Laracy, 2012). Systemic factors
also play a role in the academic outcomes of students with ADHD as some features of the special education processes impede efforts to address students’ cognitive deficits. This includes the only weak mechanisms for supporting parents to effectively participate in the creation of IEPs for their children (DeRoche, 2015; Trainor, 2010; Wiener & Daniels, 2016). Finally, the literature review will examine the central role of teachers, their limited knowledge of ADHD, their lack of adequate training, their often poor relationship with students, and, consequently, their inability to help students with ADHD reach their full potential (Bussing et al., 2001; Guerra & Brown, 2015; Jones & Chronis-Tuscano, 2008; Rush & Harrison, 2008; Weyandt et al. 2009).

Figure 2

*Conceptual Framework*
Literature Review

ADHD is Viewed as a Behavioral Problem

Throughout the history of ADHD, society viewed the disorder as a behavioral problem, and to this day the media continues to perpetuate this myth (England-Kennedy, 2008; Laurence, 2008; Neufeld & Foy, 2006). Neufeld and Foy (2006) utilized Ian Hacking’s ecological niche framework to analyze the rise of ADHD in North America. As Neufeld and Foy (2006) state, “ADHD and its precursors have always been first and foremost about behaviours [sic] in children that adults find troubling and about finding the cause and a cure, or at least a treatment, for these troubling behaviours” (p. 454). They called the troubling behaviors a vice and described it as one of the main factors for the emphasis the public placed on the disorder. Elizabeth England-Kennedy (2008) wrote a sociohistorical account of media representations of ADHD using qualitative data to argue that mass media present “negatively stigmatizing models” of ADHD (p. 95) and that the stereotypes they help create, persist, and become normalized in society. Many of the examples of ADHD from films and movies between 1998 and 2008 were social satires and depicted children with ADHD as overmedicated, impulsive, rude, disruptive, and victims of the medical industry.

Laurence (2008) added to the roots of the inaccurate description of ADHD by examining the research from the last century. She found a shift in understanding as coinciding with a historically significant metaphor of the business person who needs to control when and where to direct attention. Therefore, Laurence (2008) believes that the disorder should be called ‘executive function disorder’ to connote the actual problem. Behaviors are visible and can be observed, making it easier for people to understand. However, executive control is mostly invisible, and the science to support it is new.
Society and the school system still use this outdated model of ADHD as a behavioral problem, and it influences the decisions about how to intervene. Educators often make the argument for the ‘flow-over effect’ which is the belief that if a student is better behaved, the result will be improved educational outcomes (Purdie, Hattie, & Carroll, 2002). As a result, schools often employ behavioral techniques to help ADHD students in the classroom with the faith that it will help the students achieve academically (Spiel, Evans, & Langberg, 2014). However, Purdie, Hattie, and Carroll (2002) demonstrated that little evidence of the flow-over effect exists.

**Executive Function and ADHD**

Theories of executive function in ADHD. The models of executive function (EF) include inhibition, shifting attention between cognitive tasks, and utilizing working memory all with the purpose of achieving a goal (Chan, Shum, Touloupolou, & Chen, 2008; Georgiou & Das, 2016). Barkley (1997) defined inhibition as the ability to withhold a response, delay responding, stop a response, and resist distraction during a cognitive event. The definition of working memory initially posed by Baddeley and Hitch (1974) aimed to replace the concept of short-term memory which was too narrow in its classification as a temporary storage place for information. Most researchers now use the definition of working memory (WM) as the storage, rehearsal, processing, maintenance, and manipulation of temporarily held phonological and visuospatial information (Baddeley, 2007). EF and its components of inhibition, shifting, and working memory are crucial for learning and, therefore, for helping understand why students with ADHD struggle academically.

There are competing cognitive theories that go beyond the medical symptoms identified in the DSM-5. The competing theories debate the primary role of the central executive in
ADHD and whether inhibition or working memory is the primary deficit. Barkley’s (1997) seminal work outlined a theory of executive control that emphasized inhibition as the primary deficit of ADHD and believed that other neuropsychological components such as working memory (WM) depended on it. In contrast, Baddeley (2003) placed working memory as the primary executive function deficit of ADHD. Baddeley’s (2003) model of working memory maintained that the central executive controls and coordinates three components of WM: visuospatial sketchpad, episodic buffer, and phonological loop. Baddeley and Larsen (2007) placed the central executive at the top of the hierarchy and demonstrated that it reacts to attentional demands, serves as a link between WM and long-term memory (LTM), and coordinates two memory subsystems: short-term phonological memory (PH) and visuospatial short-term memory (VS). The PH subsystem processes auditory information, temporarily stores it, and manipulates it. The VS subsystem completes the same tasks for visual and spatial information. The episodic buffer integrates the different subsystems and stores the necessary relevant information. Despite the differences in the placement of WM in the hierarchy of executive function, all three models place a tremendous emphasis on the importance of WM, executive control, and their impact on students with ADHD.

**ADHD and studies of the extent of executive function deficits.** High school students with ADHD frequently suffer from executive function deficits (EFD), and it is a significant factor contributing to their academic underachievement (Biederman et al., 2004; Lambek et al., 2011). Biederman et al. (2004) researched the extent of EFD in ADHD students and found that 33% of the participants (n=484) with ADHD also had EFDs even after adjusting for other factors such as gender, age, intelligent quotient (IQ), learning disabilities, and socioeconomic status (SES). They also assessed the degree that ADHD and EFD affected school functioning and
found that ADHD participants with and without EFD performed significantly worse on all academic measures of school functioning and achievement. ADHD +EFD performed worse than ADHD – EFD. These findings demonstrate that students with ADHD and a comorbidity of EFD are the most at risk for academic underachievement and poor educational performance. Lambek et al. (2011) expanded the previous research of Biederman et al. (2004) by stratifying children of the same age, i.e., 7-year-old with a 7-year-old, instead of an age range such 7-10. Using this approach Lambek et al. (2011) found that 60% of the ADHD group had EFD compared to the 33% that Biederman identified. Additionally, they found that EFD remained similar in children and adolescents suggesting the disorder is stable with age. Biederman et al. (2004) did not account for developmental differences as a variable when constructing the stratification of groups and thus the results are difficult to generalize. The percentage of ADHD students with EFD is most likely in the higher range identified by Lambek et al. (2011) due to their more precise stratification, a larger comparison group of non-ADHD students (n=207), and definition of EFD according to age. The results from both studies suggest that EFD is a significant impairment to academic success for many students with ADHD even if the percentage identified by Lambek et al., (2011) has not yet been replicated and given the limitations discussed for Biederman et al. (2004).

**Executive function deficits and math.** Many of the academic problems students with ADHD face in math are a result of their EFDs (Bull & Scerif, 2001; Espy et al., 2004, Gerst, Cirino, Fletcher, and Yoshida, 2015). Bull and Scerif (2001) found that working memory, a component of executive function, accounted for the largest amount of variance in mathematical ability even after controlling for IQ and reading ability (Bull & Scerif, 2001). Espy et al. (2004) added to this research by studying the development of working memory in preschool children.
They found that working memory, shifting, and inhibitory control are related to “emergent mathematical proficiency” (Espy et al., 2004, p. 478). A limitation of these studies as applied to high school students is the age range of participants as Bull and Scerif (2001) sampled students ages 7-9 and Espy et al. (2004) included participants from 2 to 5 years of age. However, both studies demonstrated a developmental link between executive functions of working memory, inhibitory control, and mathematical abilities. Gerst et al. (2015) correlational analyses of students in 4th and 5th grade expanded the link between EF and mathematical abilities. In contrast to the previous studies, they found that all four EF processes (working memory, planning, inhibition, and shifting) predicted mathematical performance, with inhibition and planning as the strongest forces for mathematical abilities. The results discussed above suggest that there is a clear link between executive function and mathematical abilities, but the results may not generalize to high school, and thus more research is needed.

**Executive function deficits and reading.** ADHD students with executive function deficits often exhibit reading problems too. Gerst et al. (2015) in their previously mentioned correlational study found that “working memory, planning, inhibition, and shifting accounted for 50%, 35%, 21% and 28% of the variance, respectively, in reading scores” (p. 12). Additionally, they concluded that working memory scores were the strongest predictors of reading comprehension ability. Friedman, Rapport, Raiker, Orban, and Eckrich (2016) utilized Baddeley’s (2007) model of the central executive’s role in reading and expanded it by examining the covert processes of translating visual text into phonological (PH) code. They concluded that in addition to working memory deficits of the central executive system, orthographic conversion deficits contributed to reading comprehension difficulties of students with ADHD. Taken together, these studies support hypotheses regarding the important role of executive function in
reading. As Friedman et al. (2016) stated, reading is a task that exerts pressure on the limited capacity of the central executive because one must orthographically encode, covert to phonological code, store the information in short-term memory (STM), decipher the relevance of the information, update as new information arrives, connect the current information in STM to relevant material in long-term memory, and, do all of this while maintaining attention and inhibiting irrelevant information. Gerst et al. (2015) and Friedman et al. (2016) provided quantitative evidence to support this theory and demonstrated that EF and its components of inhibition, shifting, and working memory must work concurrently to support effective reading. Reading ability and comprehension are crucial for academic success, and thus, EFDs are among the most significant factors contributing to the underachievement and performance in schools for students with ADHD.

**Working memory.** Working memory problems play a substantial role in the EFD of ADHD students that contribute to academic problems. Schreiber et al. (2014) utilized a multisite controlled study to determine that children with ADHD scored significantly worse on the working memory task compared to the controls. Additionally, working memory deficits accounted for 23.8% of the variation in learning problems. Mattfeld et al. (2016) confirmed Schreiber et al. (2014) with an examination of the functional brain differences in working memory abilities of people diagnosed with ADHD as they performed a 2-back and 3-back memory test. The test asks participants to remember the location of a square on a computer screen. On the 2-back test, they must identify if the square is in the same position as presented two screens earlier. The 3-back test repeats the same procedure, and the participants must remember from three screens earlier. The impaired ADHD group demonstrated worse performance on the 2-back and 3-back memory tests compared to the control and unimpaired
ADHD groups. Additionally, they exhibited lower levels of brain activation in regions responsible for working memory such as the dorsolateral prefrontal cortex, inferior frontal junction, parietal cortex, basal ganglia, and cerebellum when performing the 2-back and 3-back trials. Van Lieshout et al. (2016) conducted a longitudinal study that added evidence by establishing that better working memory and smaller reaction time variability predicted fewer ADHD symptoms six years later even after considering covariates such as age, gender, pharmacological treatment and others. Together, these three studies convincingly demonstrated that working memory impairment is a significant problem associated with ADHD students and one that can cause poor long-term outcomes if not addressed.

**Working memory and attention.** Gathercole, Alloway, Kirkwood, Elliott, Holmes, and Hilton (2016), studied the connection between working memory and attention in students aged 4-5 and 9-10 who received a diagnosis of ADHD. The researchers found that inattentive behavior and working memory function were closely associated. They hypothesized that working memory problems and inattentive behavior might co-occur because the students have inadequate storage and processing capacity that is needed to navigate classroom activities successfully. Seymour, Mostofsky, and Rosch (2016) confirmed the link between working memory and attention when they demonstrated that children with ADHD had deficient response inhibition and increased intra-subject variability (ISV) as a group. The researchers utilized ISV to measure the construct of attention because it refers to moment-to-moment behaviors measured in seconds or milliseconds instead of hours or days. An increase in ISV is an indication that students with ADHD are losing attention and therefore the ISV for reaction time (RT) increased in children with ADHD. The research by Seymour et al. (2016) added to the previous studies by including gender as a factor and examining response control and measuring attention. The researchers
utilized a simple Go/No-Go task which asked participants to press a spacebar as fast as possible when they saw a green spaceship on the screen and not a red one. The complex Go/No-Go increased the cognitive load by asking participants to press the spacebar for a green spaceship and for a red spaceship that was preceded by an even number of green spaceships. Boys demonstrated impairment on both the simple and complex Go/No-Go (GNG) tasks compared to the control group of typically developed (TD) children, whereas girls only showed impaired performance on the complex GNG compared to the control. Taken together with previous findings on the executive control deficits in ADHD, this study provides further evidence that EC is a complex system with many different facets. The increased engagement of the EC in the complex GNG task is associated with an overload of the working memory system in children with ADHD. L Shalev, Kolodny, N Shalev, and Mevorach (2016) studied 9th and 10th-grade students with ADHD and a comorbidity of other learning deficits in a controlled experiment of attention. They added to the previous studies by differentiating attention into three different types: sustained attention, selective spatial attention, and executive attention. They found that the multiple deficits group demonstrated significantly slower reaction time on all three measures of attention. These three studies demonstrate a link between ADHD, working memory, and problems with attention.

Kofler et al. (2014), however, led a team of researchers in a study of the central executive (CE) and its subprocesses to determine the primary factors of ADHD cognitive deficits. They wanted to determine if intra-individual variability is a primary subset of ADHD cognitive deficits or if working memory affects the reaction time (RT) differences, which are measures of intra-individual variability. They sampled 37 boys ages 8 to 12 and divided them into two groups: ADHD and typically developing children (TD). They found that RT and
working memory strongly correlated across most comparisons and that CE was related to both RT and working memory ($r = -.42$ to $-.64$). Additionally, they found that $88\%$ to $100\%$ of between-group differences in RT variability was a result of CE working memory. Therefore, CE working memory appears to play a stronger role in RT variability instead of vice versa suggesting that CE working memory is the primary factor of cognitive impairment in children with ADHD.

This study supports previous and subsequent research that students with ADHD have significant deficits in working memory (Kofler et al., 2014; Mattfeld et al., 2016; Schreiber et al., 2014; van Lieshout et al., 2016). Kofler et al. (2014) added to the research by showing that working memory of the CE was the primary factor of RT. Their findings provide further evidence that the diagnostic model of ADHD as an attentional problem is limited. ADHD is a multifaceted disorder with impairments in executive function in addition to attention which together contribute significantly to academic impairment (Biederman et al., 2004; Kofler et al., (2014); Lambek et al., 2011). Additionally, Kofler et al. (2014) demonstrated that working memory and not inhibition was the primary factor in EFD as Baddeley (2007) proposed in the theoretical debate with Barkley (1997). Engelhardt, Nigg, Carr, and Ferreira (2017) provided further evidence that WM and not inhibition as factors of ADHD cognitive impairment. Their controlled study of 283 adolescents, of which 115 had ADHD, examined the role of inhibition and WM by the use of sentence processing task. Participants had to suppress incorrect information and WM. They found that inhibition was not a problem and that WM contributed to overall reading performance. Working memory impairment is the basis of EFD for many students with ADHD and contributes to reading difficulties, worse math performance, and lapses of attention which impair students’ ability to perform academically (Bull & Scerif, 2001;
ADHD Comorbidity

ADHD and learning disabilities. Barkley (2014) in his widely referenced book about ADHD stated that comorbidity rates of ADHD and LD ranged from 33% to 45% depending on the definition used for LD. Similarly, DuPaul, Gormley, and Laracy (2013) reviewed articles containing ADHD and LD between the years 2001 and 2011 to develop estimates of the rates of comorbidity. After reviewing 17 studies, they determined the estimated range was 8% to 76%. However, much of the variation was due to different definitions of LD; thus, once they excluded writing disorder, the rates fell within 24% and 38%. While Barkley (2014) and DuPaul et al. (2013) cannot provide a precise estimate, the evidence still supports the notion that a high percentage of students with ADHD also have an LD.

ADHD and reading disabilities. One of the most common learning disabilities that students with ADHD exhibit is a reading disability (RD). Willcutt and Pennington (2000) in their study of twins ages 8-18 found that people with an RD were more likely to meet the diagnostic criteria of ADHD than those without an RD. This twin study demonstrated a genetic link for both RD and ADHD. The longitudinal study by Willcutt et al. (2007) confirmed the comorbidity of RD and ADHD and found that the association is stable over time. Additionally, they found that the comorbid group was at the highest risk for poor educational outcomes. Wilcutt et al. (2010) extended the two previous studies and examined 244 twin pairs and found that slow processing speed predicted both RD and ADHD. The three studies demonstrate a strong link between RD and ADHD and present the possibility that both stem from slow

---

1 The book was cited 8036 times according to Google Scholar as of 4/23/2017
processing speed. One limitation of the three studies is that they did not account for executive function deficits such as working memory problems which have been linked with reading difficulties and ADHD (Friedman et al., 2016; Gerst et al., 2015; Schrieber et al., 2014; Mattfeld et al., 2016; Van Lieshout et al., 2016). This limitation was addressed by Friedman et al., (2016) who found that working memory deficits and downstream orthographic conversion explain many of the reading difficulties students with ADHD exhibit.

Special Education

As a result of the difficulties the symptoms of ADHD cause for students in school, the federal government enacted a series of laws aimed at ensuring all students receive the support services they need. The following sections discuss the history of those laws and how they pertain to high school students with ADHD.

History of the laws. Students with ADHD often receive special education services as a result of two laws. The Individuals with Disabilities Education Act (IDEA) was enacted in 1975 and most recently amended in 2004. It requires the implementation of an IEP that details specific special education services to meet the needs of the child. Parents must be partners on a team from the school in the planning and oversight of the IEP document which establishes the services rendered to the student. To receive an IEP, students must meet established definitions of categorized disabilities. One of the other components of IDEA is the requirement of a free and appropriate education (FAPE) to children with disabilities. A crucial moment in the history of accommodations and the FAPE standard was the Supreme Court case, Board of Education of the Hendrick Hudson Central School District v. Rowley, 458 U.S. 177 (1982). The judicial decision stated there should be “some educational benefit” and that specialized instruction provides the “basic floor of opportunity” for specialized instruction and services. Students need
to progress from grade to grade. However, schools do not have to maximize each child’s potential (Jones, 2011). This historic moment put the academic underachievement of students with ADHD beyond the law.

Recently, the FAPE standard was challenged, and the Supreme Court issued a ruling in Endrew F. v. Douglas County. School Dist. 580 U.S. RE-1 (2017) that updated the Board of Education v. Rowley (1982). According to the new interpretation, some educational benefit and progressing from grade-to-grade are not sufficient to meet the FAPE standard. A child must make progress “appropriate in light of the child’s circumstances” (pp. 11-12). However, students with disabilities do not have to progress at the same rate as nondisabled children. This new ruling mandated that accommodations provided in IEP for special education students must enable them to reach their full potential, but the FAPE standard does not define what that means.

In addition to IDEA, Section 504 of the Rehabilitation Act (1973) is an additional regulation commonly applied for students with ADHD (Holler & Zirkel, 2008). The law prohibits discrimination against an individual because of their disability.

An “appropriate education” under Section 504 is defined as the provision of regular or special education and related aids and services designed to meet individual educational needs of children with disabilities as adequately as the needs of children without disabilities are met and that comply with procedural requirements (Byrnes, 2008; Weyandt et al., 2009).

Section 504 requires the creation of a 504 plan but does not explain specific details of how schools should create it (Jones, 2011).

**Accommodations for ADHD lack efficacy.** As a result of IDEA (2004) and Section 504 of the Rehabilitation Act (1973) school districts often must create IEP or 504 Plans designed to
mediate the effects of ADHD. One component of an IEP is the implementation of accommodations designed to help the students within the regular education classroom. Yet, many of the most common accommodations in IEP and 504 plans lack efficacy or do not provide a differential boost. Spiel, Evans, and Langberg (2014) coded the accommodations written on the IEP of 326 students with ADHD. The results from the IEP coding demonstrated that 90.9% of the students had academic concerns listed in their document for present levels of academic achievement and functional performance (PLAAFP) and 77.2% had an IEP with at least one goal to improve academic functioning. However, only 16.6% of all services listed met the criteria for being research-based. In fact, many of the most common services included on IEP and 504 plans had very little empirical support or mixed results at best. Similarly, Murray et al. (2014) completed an 8-year multi-modal longitudinal study that documented the use and prevalence of services for students with ADHD. They found that the majority of students with ADHD had goals that targeted academic achievement, yet one-fourth of the accommodations were not evidence-based. Taken together these two studies place the range of evidence-based accommodations between 16% and 25%.

**The extended time accommodation.** The most commonly implemented accommodation for ADHD is extended time to take a test or quiz, though it does not raise levels of achievement or provide a differential boost (Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Lewandowski, Hendricks, & Gordon 2015; Lovett & Leja, 2015; Murray et al., 2014; Pritchard et al., 2016; Spiel, Evans, & Langberg, 2014). Lewandowski et al. (2007) administered a Mathematics Calculation Test (MCT) and found that the control group outperformed the ADHD group at each time interval on all measures including processing speed, fluency, and executive functioning. The ADHD group benefitted from extended time, but the
control group benefitted even more. Therefore, the accommodations did not provide a differential boost to students with ADHD. Additionally, ADHD students fell further behind as time progressed. Therefore, longer tests may minimize any positive effects of extended time for ADHD students. Lovett and Leja (2015) built on Lewandowski et al. (2007) by adding other predictive variables of extended time benefits such as executive functioning. They found that the higher level of reported symptoms predicted less benefit from extended time, and, in fact, a negative correlation existed between ADHD symptoms and benefits from extended time. Pritchard et al. (2016) confirmed the lack of efficacy of extended time and demonstrated that it did not significantly effect reading or math scores for students in grades 3-8. Lewandowski, Hendricks, and Gordon (2015) added a dimension to the previous studies in an experiment of high school students by utilizing a computer-based (online) system known as TestTracker that collects data on various test taking skills and behavior. The results demonstrated that students with ADHD scored significantly lower on comprehension accuracy, vocabulary accuracy and decoding number correct, but did not differ on comprehension and vocabulary, reading speed, test navigation, test anxiety score, or self-perceptions of test taking than their non-ADHD peers. Students with ADHD also spent less time reading the comprehension passages and more time examining the questions. These findings suggest that the lower scores were a result of errors and not inadequate time.

Students with ADHD and EFD are most at risk for academic underachievement and performance (Biederman et al., 2004; Lambek et al., 2011). Tests are the most common measure of academic performance and achievement. Yet, the only accommodation designed for testing does not help the most at-risk students with ADHD (Lewandowski et al., 2007; Lewandowski, Hendricks, & Gordon 2015; Lovett & Leja, 2015; Pritchard et al., 2016). Therefore, Chapter 2
will examine the links between these vitally important variables: ADHD, EFD, extended time accommodation, performance, and achievement.

Parents’ inability to effectively influence the IEP process. Parents express different levels of comfort, knowledge, and capital in the IEP process and, therefore, do not always effectively advocate for their children. Trainor (2010) used semi-structured interviews of parents and focus groups and determined that parents of students with a disability such as ADHD must possess a specialized knowledge about the disability, the laws, the school processes, and educational jargon. Teachers have a significant advantage in having cultural capital compared to parents when conducting an IEP meeting because they have the technical expertise of IDEA and can acquire capital on a daily basis through sharing information, professional knowledge, and making connections as part of their daily routine (Trainor, 2010). DeRoche (2015) complemented Trainor (2010) in information she obtained from parent interviews. She found that most parents felt they were navigating the system blindly, especially if they were from lower socioeconomic backgrounds. Ong-Dean, Daly, and Park (2011) added information about socioeconomic factors in their examination of due process hearings for ADHD students in California. They found that wealthy White districts have the highest percentage (64.7%) of due process requests from parents. They note that due process is often the last resort after years of conflict and, thus, it demonstrates wealthy parents active involvement in special education. A request for a due process hearing is the last step after years of conflict with a school district and therefore may not represent the typical special education student. However, it provides further evidence of the advantage wealthy white parents have in the process because they represented nearly 65% of all hearings.
IDEA establishes that children with a categorically defined disability receive an IEP and that parental participation is required. By law, parents should be invited to IEP meetings, provide consent for testing, approve the IEP or challenge it through due process hearings in state and federal courts (Trainor, 2010; Jones, 2011; Ong-Dean, Daly, & Park, 2011). However, the qualitative data obtained by Trainor (2010), DeRoche (2015), and Ong-Dean et al. (2011) demonstrated that compared to teachers, parents are less able to navigate the system effectively and influence the IEP. The problem was exacerbated for lower socioeconomic status parents.

**Teachers**

**Knowledge.** Teachers are vital to the development and implementation of accommodations for students with ADHD and many parents depend on them to help their children succeed. However, many teachers are working on an outdated belief system about ADHD and a large percentage lack even basic knowledge about the disorder and how to implement accommodations. Byrnes (2008) surveyed regular education and special education teachers and found that they varied greatly in their interpretations of the most common accommodations for students with ADHD: preferential seating, extended time, and scribing. The study concluded that most teachers misinterpret accommodations and thus are unable to remove barriers associated with the disability. Weyandt et al. (2009) utilized a questionnaire with 24 statements (some true and some false) about ADHD and a Likert Scale. They concluded that the knowledge of ADHD possessed by the general education and special education teachers was limited and there was not much difference between the two groups. Guerra and Brown (2015) added to the two previous studies by surveying 107 middle school teachers in Texas. They found the teachers lacked knowledge of ADHD and only accurately identified information about the disorder 46% to 66% of the time.
Students with ADHD confirmed that their teachers lack the ability to help them with their disorder. Wiener (2016) used semi-structured interviews and collected documents such as notebooks and report cards of adolescents aged 14-16 with ADHD. The students stated that most of their teachers were not informed about ADHD or how to support their deficiencies best. Baker and Scanlon (2016) conducted focus groups of secondary students with high incidence (HI) disabilities such as ADHD. Their study added to Wiener (2016) because a common theme was the students’ inability to ensure their accommodations get carried out in the general education classroom. Therefore, the responsibility falls on the teachers, and the previous studies demonstrated that the teachers lack the knowledge to do so.

**Relationships.** In addition to having a lack of knowledge of ADHD, teachers view students with the disability negatively, and it affects their emotional connection in the classroom. Shifrer (2013) analyzed data from the Educational Longitudinal Study of 2002 and determined that teachers perceived disabilities at higher rates for learning disabled (LD) students and predicted lower expectations compared to the control group of students with a similar background. Martin (2014) found a strong comorbidity of ADHD and other Specific Learning Disabilities (SLD). Therefore, the present study on LD is applicable but potentially limited by the fact that not all students with ADHD have an LD. Therefore, the Shifrer (2013) study may only generalize to the comorbidity group of ADHD. Rogers et al. (2015) expanded the previous study about ADHD student-teacher relationships by examining the results of the Classroom Working Alliance Inventory completed by elementary school students and their teachers in an urban area of Canada. Teachers reported that they had less of an emotional connection with ADHD students and found them more difficult to teach. The ADHD students reported a weaker bond with their teachers and a gender gap existed, with female students with ADHD reporting
less emotional attachment to their teachers than male students. Together these two studies demonstrate that students with ADHD are at a disadvantage in the classroom because their teachers do not set the same high expectations for them or connect as well with them as they do with non-ADHD students. The studies have several limitations, however, because neither study may fully generalize to high school students in the United States due to the small sample size, the difference in ages, and the context of the studies.

**Training and education.** Bussing, Gary, Leon, Garavan, and Reid (2002) surveyed general education teachers to examine their perceptions, knowledge, and self-efficacy in regard to teaching students with ADHD. They found that ADHD training varied with teaching experience and was negatively correlated with levels of training. Across all five districts, teachers reported the lowest confidence in their ability to manage stress caused by ADHD students, followed by low confidence in their ability to adjust teaching materials. Furthermore, teachers indicated that their biggest challenges were (in decreasing order): class size, the time needed for interventions, the severity of the child’s problem, and lack of training. Rush and Harrison (2008) utilized a completely different approach in an exploratory study aimed at creating hypotheses for future studies and in the process confirmed Bussing et al. (2002). They asked teachers to sort index cards with information about ADHD into themes, and then the researchers coded the themes into concept maps with hierarchical clusters based on the teachers sorting. They concluded, “The inclusion of both types of themes in cluster 5 suggests that both expanding general knowledge about ADHD and increasing skills in using ADHD intervention strategies are important elements to teachers’ overall perceptions of adolescents with ADHD” (p. 219). This finding demonstrated that both the high confidence and low confidence clusters were strongly related to an increased need for teacher training.
Martinussen and Tannock (2011) confirmed the hypotheses of Bussing et al. (2002) and Rush and Harrison (2008) with a survey of general and special education teachers in Ontario, Canada. They found that many of the general and special education teachers did not receive moderate/extensive in-service training in ADHD with general education teachers receiving significantly less. The general education teachers who reported receiving extensive training were much more likely to implement behavioral and instructional management strategies. Additionally, there was not a strong correlation between teachers’ experience level and reported use of behavioral and instructional management strategies indicating that all experience levels of teachers could benefit from additional training.

Jones and Chronis-Tuscano (2008) conducted a randomized controlled study of the efficacy of in-service programs designed to educate teachers about ADHD. This study highlighted many of the problems associated with teachers’ ADHD training and lack of knowledge. Six elementary schools for the metropolitan Washington, DC area participated in the study which consisted of an in-service training for the experimental group conducted by advanced doctoral students. They presented information on an overview of the disorder, evidence-based treatment, and specific behavior management strategies. The experimental and a control group that did not receive the in-service were assessed one month later with a true/false quiz and a self-reporting measure of behavioral interventions used. The effects on knowledge and use of evidence-based behavioral strategies were small.

The Jones and Chronis-Tuscano (2008) study demonstrated that teacher in-service for ADHD produced little results in teacher knowledge and use of behavioral strategies. In addition to the failure to produce the desired results in teacher training, the assumptions they made in their study demonstrated a fundamental contributing problem for ADHD underachievement. The
in-service training provided as part of the study provided the psychological overview of ADHD based on the diagnostic criteria of attention and hyperactivity. Additionally, they provided evidence-based research for behavioral intervention strategies. The cognitive deficits of students with ADHD never received mention, and many current studies demonstrate that it is executive functioning deficits and working memory problems, more than behavioral problems that contribute to significant academic underachievement (Biederman et al. 2004; Loe et al. 2008). Even if the study did produce the efficacy they sought, at best it would have improved the behavior of ADHD students while continuing to fail at improving academic results.

Conclusion

The historical roots of ADHD and cultural portrayals of the disorder in the media lead people to believe that it is a behavioral problem (EnglandKennedy, 2008; Laurence, 2008; Neufeld & Foy, 2006). However, many high school students with ADHD have cognitive deficits in the information processing system (Biederman et al., 2004; Lambek et al., 2011). They demonstrate high levels of working memory deficits which lead to problems in math and reading (Bull & Scerif, 2001; Friedman, Rapport, Raiker, Orban, & Eckrich, 2016; Gerst, Cirino, Fletcher, & Yoshida, 2015). As a result, working memory deficits are a significant contributor to learning problems in ADHD students (Kofler et al., 2014; Mattfeld et al., 2016; Schreiber, Possin, Girard, & Rey-Casserly, 2014; van Lieshout et al., 2016). Additionally, there is a high comorbidity of ADHD with learning and reading disabilities that negatively affect a students’ ability to perform in the classroom (Barkley, 2014; DuPaul, 2013; E. G. Willcutt & Pennington, 2000; E. Willcutt et al., 2007). Due to their cognitive impairments and the mistaken beliefs
about the disorder, high school students with ADHD exhibit significant academic underachievement and performance (Barkley, 1997; Loe & Feldman, 2007).

The cognitive impairments and disabilities of students with ADHD make them eligible to receive special education services to help mediate the effects in school. However, most of the accommodations implemented for ADHD lack efficacy (Lewandowski, Hendricks, & Gordon, 2014; Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Lovett & Leja, 2015; Murray et al., 2014; Spiel, Evans, & Langberg, 2014). The most common accommodation for ADHD, extended time on tests, does not provide a differential boost to students with ADHD or significantly improve performance (Lewandowski et al., 2014, 2007; Lovett & Leja, 2015; Murray et al., 2014; Pariseau et al., 2010; Pritchard et al., 2016). Parents express different levels of comfort, knowledge, and capital in the IEP process and, therefore, do not always effectively advocate for their children (DeRoche, 2015; Ong-Dean, Daly, & Park, 2011; Trainor, 2010). They expressed that they were navigating the system blindly (Trainor, 2010). As a result, they rely on the teachers to develop and implement an IEP in the best interest of their children, but Byrnes (2008) demonstrated that teachers vary in their interpretations of accommodations. Additionally, general education and special education teachers exhibit a lack of knowledge of ADHD (Weyandt et al., 2009).

Teachers have the greatest opportunity to help students with ADHD achieve, but according to Shifrer (2013), they lower expectations for them. Teachers report less of an emotional connection to their ADHD students and female students with the disorder reciprocate those feelings (Roger et al., 2015). Many teachers do not receive adequate training and feel stressed about trying to meet the needs of their ADHD students (Bussing et al., 2002; Martinussen & Tannock, 2011; Rush & Harrison, 2008).
According to the Center for Disease and Prevention Control, nearly 11% of children ages 4-17 received a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) as of 2011 (Visser et al., 2016). Not known, however, is the extent to which the problem exists in suburban public high schools, the degree to which working memory deficits are present, and if the accommodations are implemented effectively with remediation of the students’ cognitive deficits. The study in the next chapter was aimed to provide evidence regarding levels of working memory deficits, accommodations implemented, and the impact they have on academic performance and achievement of high school students with ADHD.
Chapter 2

Millions of students in the school system in the United States have Attention-Deficit/Hyperactivity Disorder (ADHD) according to the Centers for Disease and Prevention Control (Visser et al., 2016). School districts are required to provide support for many of the students with ADHD in the form of Individualized Education Programs and 504 plans, but much evidence shows that the implemented accommodations fail to raise the level of academic achievement and performance of the students (Barkley, 1997; IDEA, 1975; Loe & Feldman, 2007; Murray et al., 2014; Rehabilitation Act, 1973; Spiel, Evans, & Langberg, 2014). Potential factors associated with the underachievement of high school students with ADHD are the prevalence of executive function deficits (EFD), including working memory (Biederman et al., 2004; Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Lambek et al., 2011; Mattfeld et al., 2016; Schreiber, Possin, Girard, & Rey-Casserly, 2014; van Lieshout et al., 2016; Wilcutt et al., 2005). The purpose of the following chapter is to determine if the high school students with ADHD at a local suburban school district in Pennsylvania demonstrate lower academic performance and achievement, exhibit working memory deficits, and to establish if the accommodations utilized in IEP meet the criteria of evidence-based established by Spiel et al. (2014).

Introduction to the Problem of Practice in Context

In a preliminary study at Nest View High School located in a suburb of Philadelphia, Pennsylvania, qualitative evidence gathered from interviews with faculty involved in the special education process confirmed the high prevalence of IEPs for students with ADHD, accommodations that lacked efficacy including extended time, and executive function deficits in ADHD students. Since nearly 11% of children ages 4-17 in the United States had received a
diagnosis of ADHD as of 2011 (Visser et al., 2016), it was not surprising to learn in an interview with a special education teacher at Nest View High School that fifteen of the seventeen students on her caseload had an IEP for ADHD (Appendix B). This finding indicates a likely high presence of ADHD students.

All three faculty members interviewed for the preliminary study explained that the school psychologist is responsible for creating the accommodations, but that occasionally the special education teacher or guidance counselor provides input (Appendix A, B, and C). The special education teacher said she often “asks the teachers” to determine what works (Appendix B). Studies indicate that teachers often lack knowledge of ADHD and how to implement accommodations (Bussing et al., 2002; Byrnes, 2008; Guerra & Brown, 2015; Martinussen et al., 2011). The school psychologist stated that she creates the accommodations “from experience” and tries to keep them as “general” as possible. The psychologist was unable to identify the resources used to inform design of the accommodations created for the specific deficiencies identified by the tests (Appendix C). This observation supports Spiel, Evans, and Langberg (2014) who found that only 16.6% of accommodations for ADHD are evidence-based.

Additionally, the school psychologist said there are no accommodations for working memory impairment, which is a prevalent and often most significant executive function deficit associated with ADHD (Biederman et al., 2004; Kofler et al., 2014; Lambek et al., 2010; Schreiber, Possin, Girard, & Rey-Casserly, 2014).

Research indicates that extended time for test-taking is the most common accommodation provided despite the lack of evidence showing it is effective (Lewandowski et al., 2014, 2007; Lovett & Leja, 2015; Murray et al., 2014; Pariseau et al., 2010, Pritchard et al., 2016). There were mixed reactions regarding its efficacy in the faculty I interviewed. The guidance counselor
believed the accommodation “doesn’t make sense,” however, the special education teacher stated it is needed because students with ADHD exhibit slow processing speed. Slow processing speed is a deficit that many learning disabled students, as well as those with ADHD, exhibit. The school psychologist confirmed the opinions of the special education teacher. She added that extended time should be utilized in conjunction with the alternative testing environment accommodation. They all agreed that it was the most common accommodation used at the high school for students with ADHD.

Based on their statements, the special education teacher and school psychologist were both aware that students with ADHD have executive function deficits (EFD). However, the only accommodation example they could provide that targeted EFD was the use of an alternative testing environment which the special education teacher and school psychologist stated is intended to help the students’ avoid distractions in a typical classroom (Appendix B & C). Additionally, the psychologist stated that she assesses students using the Weschler Intelligence Scale for Children (WISC) which includes measures of working memory, but also indicated that she is unaware of any accommodations for working memory problems (Appendix C).

Goals and Objectives

In preliminary faculty interviews, staff involved in Special Education indicated that most of their caseload are students with ADHD. Students only receive special education services if the disorder has an impact on their education. Therefore, a high percentage of students with ADHD in the school suffer academically, and further research is needed to quantify the extent of their learning problems. Therefore, the primary goal of this study is to determine if students with ADHD at a Nest View High School in Pennsylvania demonstrate significant academic underachievement, underperformance, and to what extent.
Additionally, the staff confirmed that there is a lack of evidenced-based accommodations, that the extended test accommodation is common, and that working memory deficits can be identified in neuropsychological evaluations. Therefore, the secondary goals are to gather further evidence to determine the extent to which these problems exist and the impact they have on student outcomes. The following research questions will guide the study.

Table 1

*Needs Assessment Research Questions*

**RQ1:** What are the levels of academic achievement and performance of high school students with ADHD at Nest View High School?

**RQ2:** To what extent are working memory deficits identified in Nest View High School students with ADHD?

**RQ3:** What accommodations are in place for students with ADHD at Nest View High School?

**RQ4:** To what degree do accommodations impact academic achievement for ADHD students at Nest View High School?

**RQ5:** To what degree do working memory deficits impact academic achievement and performance of ADHD students at Nest View High School?

**Methodology**

**Participants.** The *Diagnostic and Statistical Manual 5*th Edition (DSM-5) establishes the medical criteria for a diagnosis of ADHD. However, schools only identify students if the disability affects their education. As a result of this distinction, participants for the present study must meet the criteria established by the schools instead of the DSM-5. At Nest View, any new referrals of ADHD from a parent, teacher, or doctor go to the child study team, which consists of guidance counselors, an administrator, the school psychologist, school nurse, and the Response to Intervention and Instruction (RTII) teacher. The child study team must have signed documents from the parents for permission to evaluate. The next step involves collecting data
from teacher observation forms, attendance records, grades, standardized test scores, and disciplinary infractions. If they determine that ADHD is affecting the students’ academics, they create trial interventions for the student and reconvene later to determine if the interventions succeeded. If not, they could proceed to cognitive assessments and behavioral rating scales administered by the school psychologist. The guidance counselor indicated that this round of testing is the last resort, but the school psychologist stated that testing for an IEP is recommended by the school district’s lawyers. It is the school psychologist that determines if an IEP or 504 plan is appropriate, but the previous steps must be completed first. Students with the medical diagnosis of ADHD who are not identified by the school will not be included in this study because it does not impact their education and they, therefore, are not known by school personnel.

The population for the present study is high school students (grades 9-12) at a suburban high school in Pennsylvania with an IEP that lists “Other Health Impairment” as their primary or secondary disability (N=42). A student with ADHD cannot receive an IEP unless they also meet the requirements of a specific disability. Therefore, ADHD is typically listed as “Other Health Impairment” on the IEP. The initial sample of participants comprised seven students whose parents returned the consent/assent form. Two respondents were excluded from the study because their IEP did not indicate “Other Health Impairment” and, therefore, did not meet the criteria for ADHD.

The documents of one respondent indicated a 504 plan instead of an IEP, and, that student, therefore, was not included in the study. IDEA, which was enacted in 1975 and most recently amended in 2004, established the criteria for an IEP. It is different and more extensive than Section 504 of the Rehabilitation Act in several regards. To receive an IEP, students must
meet categorical definitions of disabilities, whereas a 504 does not list specific disabilities, but instead focuses on the functions. This distinction makes it difficult to differentiate whether students receive a 504 plan for ADHD or for some other reason. The services provided on IEP are much more extensive than a 504 plan. Additionally, students with ADHD receive an IEP instead of a 504 plan if the disability has a greater impact on their education as determined by the evaluations described above. Thus, ADHD students with an IEP are most at risk for academic underachievement and underperformance.

The final sample consisted of 4 students aged 14-18 (M=16.5) in grades 9-12 that met the criteria of having an IEP for “Other Health Impairment.” Three were male and one was female.

Measures. There are four main constructs in the present study: academic achievement, academic performance, accommodations, and working memory.

Academic achievement and performance. Academic underachievement was defined by Loe and Feldman (2007) as “problems in learning and applying knowledge, including earning poor grades and low standardized test scores” (p.644). They defined academic performance as “completing classwork or homework” (p. 644). These two definitions overlap because earning poor grades, used as a measure of low academic achievement, is dependent on completing homework and classwork, which they include as an indicator of academic performance. To separate these two variables, I defined academic achievement as the ability to learn and apply knowledge on standardized tests and academic performance as the levels of accomplishment in regular education classes as demonstrated by scores on homework, classwork, quizzes, projects, and course exams.
Key variables used to determine academic achievement are standardized test scores. The key indicators I used are the scores obtained from the Pennsylvania Department of Education Keystone Exam in the areas of Algebra, Biology, and Literature or the students’ scores obtained on the 8th-grade Pennsylvania System of School Assessment (PSSA) Exams. Exam administration occurs every year across the state of Pennsylvania in all public schools, and most students typically take the Keystone exams by grade 11. Students receive one of four scores on each of the exams. The possible scores are listed here in ascending order: below basic, basic, proficient, and advanced (Wolf, 2016). According to Pennsylvania Code Title 22, Chapter 4, section 4.4 (d)(4), students may choose to opt out of the exams if the parents of the child submit a letter stating that it conflicts with their religious beliefs. Otherwise, the Pennsylvania State Department of Education expects that every student takes the exams. For this study, 8th-grade PSSA exam scores replaced Keystone exam scores if any student had not yet taken the Keystones, as may be the case with some of the younger high school students.

I used two additional key indicators of academic performance: grade point average (GPA) and class rank. To calculate GPA, one finds the sum of quality points and divides by the total number of credits. Students are ranked in order of highest to lowest GPA with a score of 1 given to the student with the highest GPA.

Students at the high school are required to complete 23.8 credits to graduate with each full year class counting as 1.0 credit (Table 2). Grades and quality points for each class were calculated on the grading system below (Course Selection Guide, 2017). Each 1.0 credit course consists of many different assignments, quizzes, and tests that combine for the final grade in the course. Therefore, GPA and class rank are mean scores of all the coursework a student completes in high school making it a valid indicator of academic performance as defined above.
Table 2

Grading System

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Percentage</th>
<th>Quality Points-Advanced Placement</th>
<th>Quality Points-Accelerated Honors (Formerly Seminar)</th>
<th>Quality Points-Honors</th>
<th>Quality Points-Career and College Prep (Formerly Academic)</th>
<th>Quality Points-Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>97-100</td>
<td>5.7</td>
<td>5.2</td>
<td>4.7</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>A</td>
<td>93-96</td>
<td>5.5</td>
<td>5.0</td>
<td>4.5</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>A-</td>
<td>90-92</td>
<td>5.3</td>
<td>4.8</td>
<td>4.3</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>B+</td>
<td>87-89</td>
<td>4.7</td>
<td>4.2</td>
<td>3.7</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>B</td>
<td>83-86</td>
<td>4.5</td>
<td>4.0</td>
<td>3.5</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>B-</td>
<td>80-82</td>
<td>4.3</td>
<td>3.8</td>
<td>3.3</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>C+</td>
<td>77-79</td>
<td>3.7</td>
<td>3.2</td>
<td>2.7</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>C</td>
<td>73-76</td>
<td>3.5</td>
<td>3.0</td>
<td>2.5</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>C-</td>
<td>70-72</td>
<td>3.3</td>
<td>2.8</td>
<td>2.3</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>E</td>
<td>60-69</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>Below 60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Accommodations. According to Harrison, Bunford, Evans, and Owens (2013), there is no consensus definition of “accommodation” in education. They propose “accommodations are changes to practices in schools that hold a student to the same standard as students without a disability but provide a differential boost to mediate the impact of the disability on access to the general education curriculum” (p. 556). I included any specifically designed instruction (SDI) in an IEP as an accommodation, even if science does not support a differential boost as Harrison et al. (2013) defined. They urged educators to adopt this definition. However, IDEA does not require a differential boost, and thus it was not included in my definition. The accommodations were coded according to Spiel, Evans, and Langberg’s (2013) criteria for evidence-based accommodations (p. 459). Accommodations were listed as evidence-based if they met all the criteria (R, 1, 2, 3).
Table 3

Coded Accommodations According to Spiel, Evans, and Langberg (2013)

<table>
<thead>
<tr>
<th>Service</th>
<th>Description of service category</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended time</td>
<td>Increased time allotted for tests, quizzes, projects, or assignments</td>
<td>R, 1, 3</td>
</tr>
<tr>
<td>Small group</td>
<td>Instruction or testing in small group</td>
<td>R, 2</td>
</tr>
<tr>
<td>Prompting</td>
<td>Direct the students’ attention to the task at hand</td>
<td>R, 2</td>
</tr>
<tr>
<td>Test aids</td>
<td>Allowed the use of calculator or notes during tests</td>
<td>R</td>
</tr>
<tr>
<td>Read-aloud</td>
<td>Allowing students to read instructions, test, and/or quizzes aloud or have these read aloud to them</td>
<td>R, 2</td>
</tr>
<tr>
<td>Breaks</td>
<td>Providing students with additional breaks</td>
<td>R</td>
</tr>
<tr>
<td>Study support</td>
<td>Teaching skills to improve independent study of materials (developing note cards, guided worksheets)</td>
<td>R</td>
</tr>
<tr>
<td>Reduction</td>
<td>Reduced the number or length of tests or assignments while including the same content (e.g., reduce number of repetitions)</td>
<td>R, 1, 2</td>
</tr>
<tr>
<td>Behavior modification</td>
<td>Reinforcements or punishments</td>
<td>R, 1, 2, 3</td>
</tr>
<tr>
<td>One-on-one</td>
<td>Pull student out of the general education setting for one-on-one instruction or testing</td>
<td>R, 2</td>
</tr>
<tr>
<td>Modeling skills</td>
<td>Provide example or demonstration of skills or concepts</td>
<td>R, 2</td>
</tr>
<tr>
<td>Preferential seating</td>
<td>Relocated student closer to point of instruction</td>
<td>R, 1, 2</td>
</tr>
<tr>
<td>Material organization</td>
<td>Increase student organization of classroom materials or assignments</td>
<td>R, 1, 2, 3</td>
</tr>
<tr>
<td>Planner organization</td>
<td>Increase student temporal organization (e.g., daily planner)</td>
<td>R, 1, 2, 3</td>
</tr>
<tr>
<td>Adapted grading</td>
<td>Modify how projects, assignments, tests, and/or quizzes are graded</td>
<td>N</td>
</tr>
<tr>
<td>Copy of notes</td>
<td>Provide a copy of notes from class</td>
<td>N</td>
</tr>
</tbody>
</table>
Divide tasks  Breaking tasks into smaller segments  R, 2

Parent-teacher contact  Increase parent-teacher communication  R

**Note.** Codes under “Support” R = Recommended by ED, 1 = multiple studies investigating service, 2 = study or studies report(s) positive impact on academic and/or behavioral performance, 3 = adequate experimental control, N = No level of support and not included on ED list of recommended services.

**Working memory.** Kofler et al. (2014) defined working memory as “a limited capacity system responsible for the temporary storage, rehearsal, and manipulation of internally held information for use in guiding behavior” (p. 460). I utilized the scores students obtained on the Working Memory Subtests on the Weschler Intelligence Scale for Children Fifth Edition (WISC-V) or any other version of the WISC test. The Working Memory Subtests from the WISC are typically listed on a students’ Evaluation Report or Reevaluation Report and are standardized.

**Data Collection Methods**

The Superintendent of Schools approved the selection of participants and document collection. Upon approval of the study by the Johns Hopkins University, the Director of Pupil Services and the Database Specialist identified the students at the high school with an IEP for “Other Health Impairment” and sent the cover letter and letter of consent to their parents via electronic mail (See Appendices D and C). Due to a low respondent rate, a second email was sent with a link to the consent/assent form on the Johns Hopkins University Qualtrics program and the option to respond with “I consent to participate in the study.” This method yielded a higher response rate, but it was still low at only 10% of the approximately 40 students in the population (n = 4).

Upon consent/assent by the parents, the Director of Pupil Services provided me with the following key documents related to the research questions: Evaluation Reports for Special Education Services, Reevaluation Reports for Special Education Services, and IEP documents.
The technology department supplied the Report Cards and Pennsylvania Keystone Exam scores for Pennsylvania System of School Assessment (PSSA) scores.

**Initial Summary of Results**

**Pennsylvania Keystone Exam scores as measures of academic achievement.** Students must score “Proficient” or “Advanced” to pass the Pennsylvania Keystone Exam and passing the exam is a graduation requirement for the state. The four ADHD students in the present study at Nest View High School failed six out of their eight exams in Algebra, Biology, and Literature, compared to only a 7% failure rate school wide for the approximately 1,200 students. “Basic,” the lowest achievable score, was the mode for ADHD students, and none of the participants achieved the highest score of “Advanced.” The percentage of ADHD students was significantly lower at both passing marks and higher for both failure marks compared to the school results (Table 4).

Table 4

**Pennsylvania Keystone Exam Scores**

<table>
<thead>
<tr>
<th></th>
<th>Below Basic</th>
<th>Basic</th>
<th>Proficient</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADHD*</td>
<td>8%</td>
<td>67%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>School Results</td>
<td>2%</td>
<td>5%</td>
<td>55%</td>
<td>37%</td>
</tr>
</tbody>
</table>

Note. There is missing data for one participant because they transferred from another state and had not taken any Pennsylvania Achievement Exams. A second participant is in 9th grade and will complete the exams May, 2017 and receive their scores in the fall of 2017. Their 8th-grade PSSA scores were substituted.

The failure rate on the Keystone Exams of ADHD students in Nest View High School confirms Loe and Feldman (2007) who stated that ADHD students underachieve.

**Grade point average and class rank as measures of academic performance.** The participants sampled at Nest View High School demonstrated below average academic
performance as determined by their GPA (M=3.46 on a 5.7 scale) and class rank (M=198 out of 316). The students’ class ranks ranged between the 30th and 34th percentile placing them in the bottom third of all students. These findings support research that students with ADHD receive lower grades (Barkley, 1997; Kent et al., 2011; Langberg et al., 2011; Loe & Feldman, 2007).

**Identification of working memory deficits.** ADHD students in the sample that completed the WISC demonstrated significant weaknesses in working memory (M=78.5). This score placed the students in the “Low” range of scores according to the school psychologist’s report and in the bottom 10% nationally for scores of working memory. Schreiber et al. (2014), Mattfeld et al. (2016), and Van Lieshout et al. (2016) demonstrated convincingly that students with ADHD have significant weaknesses in working memory. Although the data sample in this study is small, it does provide some evidence that ADHD students at Nest View High School are among the worst performers on measures of working memory as the literature describes.

Since two of the four from the sample did not have scores for working memory, it is possible that ADHD students do not typically receive scores for working memory. If true, this hypothesis could explain why no accommodations for working memory impairments are included. Working memory deficit is mostly covert and if not specifically tested, educators most likely will not recognize it.

**Accommodations for students with ADHD.** Seventy-four percent of the accommodations on IEPs for the four ADHD students sampled at Nest View High School met the requirement of having a study or studies report a positive impact on behavioral and academic performance (Table 3). However, only 5% (n = 2) of the accommodations met the criteria of evidence-based according to Spiel et al. (2013). This discrepancy indicates that many of the accommodations refer to a single study reporting a positive outcome, but most do not cite a
second study and/or an adequate control. It confirms that only a small percentage of accommodations are listed as evidence-based by Spiel, Evans, and Langberg (2013), who reported that only 16.6% of accommodations were evidence-based.

Among the many accommodations listed on the IEP of ADHD students in the sample, only two include studies that were performed with an adequate control study (Table 5). The most common accommodation implemented was prompting, with each student having more than one SDI in this category. Providing one-on-one instruction outside of class or a change in test administration, directions, or number of distractors was the next most common. Both of these methods are recommended by the Department of Education and are supported by a study reporting a positive impact. However, neither of these accommodations meet the criteria of evidence-based established by Spiel, Evans, and Langberg (2013). Eight percent of the accommodations had no research support and are not included on the Department of Education list of recommended services.

Many studies reported that the most common accommodation for ADHD students is extended time (Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Lewandowski, Hendricks, & Gordon 2015; Lovett & Leja, 2015; Murray et al., 2014; Pritchard et al., 2016; Spiel, Evans, & Langberg, 2014). All the students in the sample from Nest View received the extended time accommodation, demonstrating its prevalence as a typical intervention for ADHD. The extended time accommodation does not raise levels of performance for ADHD students on exams (Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Lewandowski, Hendricks, & Gordon 2015; Lovett & Leja, 2015; Murray et al., 2014; Pritchard et al., 2016; Spiel, Evans, & Langberg, 2014). Lovett and Leja (2015) found that ADHD students with executive functioning deficits predicted little to no benefit from the extended time accommodation. Since the students
in the sample were either not tested for EFD or scored extremely low in working memory (bottom 10% nationally) it is likely that the extended time accommodation added no benefit.

Table 5

*Accommodations from sampled students’ IEP coded according to Spiel et al. (2013)*

<table>
<thead>
<tr>
<th>No Support</th>
<th>Recommended by the Department of Education (R)</th>
<th>Multiple Studies Investigating Service (1)</th>
<th>Study or studies positive impact on academic or behavioral performance (2)</th>
<th>Adequate experimental control (3)</th>
<th>R,2</th>
<th>R, 1, 2</th>
<th>R, 1, 2, 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum</td>
<td>3</td>
<td>29</td>
<td>4</td>
<td>28</td>
<td>3</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Discussion**

The current study confirmed previous research (Barkley, 1997; Kent et al., 2011; Langberg et al., 2011; Loe & Feldman, 2007) and established that high school students with ADHD in a suburban high school in Pennsylvania significantly underachieve and underperform academically. The sampled participants demonstrated low levels of achievement on the Pennsylvania Keystone and PSSA exams with a 75% failure rate. None of the ADHD participants achieved the highest score of “Advanced” on any of the three Keystone Exams. Additionally, the ADHD students’ academic performance placed them in the bottom 34% of the school based on GPA (M=3.46 on a 5.7 scale) and class rank (M=198 out of 316).

As expected, the working memory deficits had not always been identified in students with ADHD; though when the students were tested for it, they displayed low levels of performance. Two of the four students did not take the WISC exam, which includes subtests for working memory. This finding suggests that working memory is not always tested in ADHD students despite research indicating that deficits in working memory have been reported in 33% to 60% of these students (Biederman et al., 2004; Lambek et al., 2011). ADHD students in the
sample who completed the WISC demonstrated significant weaknesses in working memory (M=78.5) which places them in the low range indicating the bottom 10% nationally. These results suggest that working memory problems may be a significant executive functioning deficit of ADHD students at Nest View High School (Mattfeld et al., 2016; Schreiber et al., 2014; van Lieshout et al., 2016).

IDEA requires school districts to implement accommodations to mitigate the effects of ADHD. However, only 5% of the accommodations on IEP for students with “Other Health Impairment” met the criteria of evidence-based. This finding confirms the small number of accommodations listed as evidence-based by Spiel, Evans, and Langberg (2013) who reported that only 16.6% of identified accommodations met the criteria. The most common accommodation implemented was “prompting” for each student having more than one accommodation on their IEP in this category. Pulling a student out of class for one-on-one instruction or testing was the second most frequent. Both accommodations received a recommendation by the Department of Education and are supported by a study reporting a positive impact. However, both accommodations do not meet the criteria of evidence-based. In addition, all the students were provided the extended time accommodation, which, in particular, is not supported by research. Finally, 8% (n = 3) of other accommodations written on the IEP also were not supported by evidence and did not receive endorsement from the Department of Education.

**Limitations**

The most significant limitation of the current study is the low response rate (N=4). The small sample size prevents generalizing the data to the larger population of the school (N=42). Additionally, relationships between the variables could not be determined. Missing data from
several of the participants further weakened the ability to analyze the results. One participant did
not yet have an IEP completed, did not take the standardized state exams, and did not have
enough grades for the school to accurately calculate GPA or class rank.

Another limitation surfaced in the coding of the accommodations. Two of the three
accommodations that Spiel, Evans, and Langberg (2013) list as meeting all the criteria of
evidence-based may have been implemented by methods other than an accommodation.
“Planner organization” and “material organization” could be part of the students’ study skills
class or provided during their one-on-one instruction accommodation. Therefore, it is not known
if the students received this support.

**Moving Forward**

The results of the current study are aligned with research reporting that high school
students with ADHD significantly underachieve, underperform, and have a high percentage of
accommodations that are not evidence-based (Barkley, 1997; Loe & Feldman, 2007; Spiel et al.,
2013). Although not confirming the presence of a working memory deficit in the larger
population of ADHD students, the data collected from two students who were assessed on this
measure did indeed have deficits in working memory when compared to results of students
nationally. Chapter three will review literature pertaining to interventions aimed at ADHD
students WM deficits with the goal of identifying a better alternative to their current
accommodations. Though the limited amount data collected thus far and low participation rate
limit the degree to which these findings can be generalized, the data collected is in line with the
direction of this study. One possible reason for the low rate of participation is the use of email
alone to solicit parental consent/assent.
Chapter 3

Working Memory Deficits and the Academic Achievement of Students with ADHD

High school students with Attention-Deficit/Hyperactivity Disorder (ADHD) demonstrate significant academic underachievement and poor educational performance (Barkley, 1997; Loe & Feldman, 2007); they (1) receive lower grades, (2) take fewer advanced courses, (3) fail more often, (4) are rated by teachers as poor performers, (5) have poorer school attendance (which also negatively correlates with academic success), and (6) are more likely to drop out (Kent et al., 2011; Langberg et al., 2011). Many high school students with ADHD have cognitive deficits in the information processing system (Biederman et al., 2004; Kofler et al., 2014; Lambek et al., 2011; Mattfeld et al., 2016; Schreiber, Possin, Girard, & Rey-Casserly, 2014; van Lieshout et al., 2016). They demonstrate high levels of working memory (WM) deficits which predict many academic problems (Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Mattfeld et al., 2016; Wilcutt et al., 2005). The cognitive impairments and disabilities of students with ADHD make them eligible to receive special education services to help mediate the effects in school. However, that many of the typically implemented accommodations for ADHD lack efficacy has been well documented (Lewandowski, Hendricks, & Gordon, 2014; Lewandowski, Lovett, Parolin, Gordon, & Coddin, 2007; Lovett & Leja, 2015; Murray et al., 2014; Spiel, Evans, & Langberg, 2014). The most common accommodation for ADHD, extended time on tests, does not provide a differential boost to students with ADHD or significantly improve performance (Lewandowski, Hendricks, & Gordon, 2014; Lewandowski, Lovett, Parolin, Gordon, & Coddin, 2007; Lovett & Leja).

Research conducted in the spring of 2017 at Nest View, a suburban high school in Pennsylvania, confirmed previous research and established that high school students with ADHD...
significantly underachieved, underperformed, received accommodations in their IEP’s that lacked evidence of efficacy, and scored low on measures of working memory. The sampled participants failed six out of eight State exams, and had a mean class rank in the bottom 34% of the school. Only two of the accommodations on their IEPs met the criteria of evidence-based as established by Spiel, Evans, and Langberg (2013). All the students in the sample from Nest View had the extended time accommodation demonstrating its prevalence as a typical intervention for ADHD. Two of the four students were not tested for working memory deficits despite research that places the range of ADHD students with WM deficits between 33% and 60% (Biederman et al., 2004; Lambek et al., 2011). The ADHD students in the sample who completed the Weschler Intelligence Scale for Children (WISC) demonstrated significant weaknesses in working memory (M=78.5) which places them in the low range indicating the bottom 10% nationally. Based on the literature and these findings, there is a need to address the WM deficits and accommodations of students with ADHD at Nest View High.

**Theoretical Framework - The Information Processing System and Working Memory**

Atkinson and Shiffrin (1968) proposed a version of the information processing model which included information entering the senses, the perception of it, transfer to short-term memory, and further processing before the information is stored in long-term memory. The control (executive) processes the flow of information through this system. Once information is stored in long-term memory, it must be retrieved though recall, recognition, and inferential construction (Anderson, 1995; Flavell, Millers, & Miller, 1993).

Baddeley and Hitch (1974) contended that the concept of short-term memory was too narrow in its classification as a temporary storage place for information. Their original theory of working memory (WM) included three components: (1) a visuospatial sketchpad, (2) a
phonological loop, and (3) central executive. Baddeley (2012) modified the framework in the subsequent decades as new research required new components to the model and some restructuring.

Current views of WM build on the original model of WM by Baddeley and Hitch (1974) and most commonly refer to WM as the storage, rehearsal, processing, maintenance, and manipulation of temporarily held phonological and visuospatial information (Baddeley, 2003). Additionally, Baddeley (2012) contends that WM interacts with long-term memory through an episodic buffer (Figure 3). He describes the episodic buffer as a component that holds episodes in WM and connects them, when needed, to long-term memory. It serves to integrate information into a code (Baddeley, 2012).

Figure 3

Recreation of Alan Baddeley’s (2012) WM Model

WM deficits are the primary cognitive impairment for many students with ADHD and contributes to reading difficulties, poor math performance, and lapses of attention which impair
students’ ability to perform academically (Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Mattfeld et al., 2016; Wilcutt et al., 2005). One proposed hypothesis for why WM deficits are associated with so many problems is that they are a bottleneck for more advanced cognitive processes. Information must pass through WM before being utilized for other more advanced thinking such as problem solving and learning new facts or skills (Nutley & Soderqvist, 2017).

Sweller, van Merrienboer, and Paas (1998) proposed a different theory for the limitations WM have on educational attainment. They stated that complex reasoning of novel concepts, required by many instructional strategies, will be deficient for most ADHD students because their working memory does not have the capacity for this type of information processing due to the strain it places on intrinsic cognitive load. They defined intrinsic cognitive load as the ability to automatically identify and retrieve relevant schemas, which are categorized information stored in long-term memory. Intrinsic cognitive load is an interaction between the type of material being learned and the prior expertise of the learner. In contrast, students’ extrinsic cognitive load can be influenced by instructional strategies. This form of cognitive load places greater stress on the learner by the format of the instruction. For example, directions that require students to integrate multiple forms of evidence such as an image, an action verb, and further instructional text. They hypothesized that a combination of high intrinsic and extrinsic cognitive load could be “fatal to learning” (p. 263) because it can exceed ones working memory capacity (Sweller et al., 1998).

**Two Intervention Approaches for Working Memory Deficits**

According to the framework established by Sweller et al. (1998), there are two ways to help students with deficits in WM. The first is to make attentional processes automatic through
routinizing and repetition of the skill thereby limiting the intrinsic cognitive load. The second approach is to present tasks in a way that minimizes the amount of stress placed on WM which reduces the extrinsic cognitive load (Sweller et al., 1998).

Cogmed Working Memory Training (CWMT) by Pearson is one of the most extensively studied programs aimed at improving students’ WM via computerized repetitive skill development (Kirk, Gray, Riby, & Cornish, 2015). Another recent approach studied because of its connection to executive functions, including WM, is mindfulness training (Buttle, 2011). Researchers hypothesize that CWMT and mindfulness training improve students’ WM, which enables them to learn better in the classroom resulting in improved performance (Buttle, 2011; Nutley & Soderqvist, 2017; Sodervist & Nutley, 2015). CWMT and mindfulness presumably involve initiating changes to the students’ brains and mental processing by repetitive and routinized procedures thereby reducing the intrinsic cognitive load. Other strategies, often referred to as cognitive load reduction, do not intend to help students improve their intrinsic cognitive load associated with WM deficits through repetition. Instead, cognitive load reduction strategies provide teachers with methods to reduce the impact that WM deficits have on student learning and performance (Merrienboer & Sweller, 2010). According to the Sweller et al. (1998) cognitive load framework, these instructional strategies lessen the extrinsic cognitive load on ADHD students’ WM.

The following literature review examines the three widely researched approaches of CWMT, mindfulness, and cognitive load reduction as means of reducing the intrinsic and extrinsic cognitive load on ADHD students’ WM and thus improving academic performance. I discuss each of the approaches and evaluate them with respect to reported changes affected in WM and the viability of each for use in schools. Additionally, because improvement in
academic performance and achievement of ADHD students with WM deficits are the goal of this research, I use the criteria of near and far transfer effects established by researchers such as Barnett and Ceci (2002). They commonly refer to improvement on cognitive tasks that are similar to those used in training as near transfer effects, and far transfer as the training improvement on tasks that are different from the tasks trained (Barnett & Ceci, 2002). They created a taxonomy of near and far transfer based on the content of what is being transferred and the context of when and where it is transferred. Often, WM training and cognitive load reduction aim to establish transfer of modalities. For example, exercising short term-memory by reciting random telephone numbers would demonstrate near transfer if the participant improved in reciting random ten letter strings. Far transfer would consist of taking the practiced skill of memorizing digits and improving on an unrelated modality that uses short-term memory such as verbal instructions provided by a teacher during class instruction. Therefore, I will critically assess (1) CMWT, (2) mindfulness, and (3) extrinsic cognitive load reduction strategies’ ability to affect near transfer and far transfer and the potential impact on academic performance and achievement.

**Literature Review of Interventions**

**Cogmed Working Memory Training (CWMT).** CWMT is a commercially available computerized program with tasks in visuospatial and verbal working memory that adapt and become progressively harder as the user masters each activity (Pearson Education, Inc.). It was originally developed by Torkel Klingberg at the Karolinska Institute cognitive neuroscience laboratory (Simons et al., 2016). The training typically takes 30-45 minutes a day, five days a week and lasts for five to seven weeks. The user receives support from a Pearson certified coach who assists with starting up, providing weekly feedback, and helping motivate the participants.
The program can be completed by participants during school or at home. As discussed in the sections that follow, the program has high compliance rates, and is reported to improve reading comprehension, improve executive function, and to change behavior and possibly neural pathways of ADHD students (Bigorra, Garolera, Guijarro, & Hervás, 2015; Dahlin, 2011; Dongen-Boomsma, Vollebregt, Buitelaar, & Slaats-Willemse, 2014; Holmes & Gathercole, 2014; Kirk et al., 2015; Nutley & Söderqvist, 2017; Söderqvist & Bergman Nutley, 2015; van der Donk, Hiemstra-Beernink, Tjeenk-Kalff, van der Leij, & Lindauer, 2015).

Compliance rates inside and outside of schools. There are several studies that demonstrate high Compliance rates for CWMT when utilized in school or at home, with results similar to those observed in a laboratory (Bigorra, Garolera, Guijarro, & Hervás, 2015; Holmes & Gathercole, 2014; van der Donk, Hiemstra-Beernink, Tjeenk-Kalff, Leij, & Lindauer, 2015). Holmes and Gathercole (2014) conducted a study in an English primary school where two school staff members received training to install the program and supervise 22 mixed-ability children (m = 8 years, 8 months) as they worked on CWMT. The results demonstrated that over 90% of the students completed training which was defined as completing 20 or more sessions. Additionally, students improved on the training tasks at rates similar to participants who completed them in a laboratory. The small sample size and age of the participants make it difficult to determine if the results will generalize to a high school such as Nest View. However, subsequent research demonstrated high compliance rates irrespective of the participants having ADHD or the location of the training. The results of the nine studies below indicate compliance rates between 70% and 100% (See Table 6).

Table 6

Compliance Rates of CWMT

56
<table>
<thead>
<tr>
<th>Study</th>
<th>ADHD Sample</th>
<th>Age of Participants</th>
<th>Training Completed at School or Home</th>
<th>Compliance Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klingberg et al. (2005)</td>
<td>Yes (n=50)</td>
<td>M=9.8</td>
<td>Both</td>
<td>88%</td>
</tr>
<tr>
<td>Dahlin (2011)</td>
<td>Yes (n=42)</td>
<td>9-12</td>
<td>School</td>
<td>98%</td>
</tr>
<tr>
<td>Gray et al. (2012)</td>
<td>Yes (n=52)</td>
<td>12-17</td>
<td>School</td>
<td>87%</td>
</tr>
<tr>
<td>Chacko et al. (2014)</td>
<td>Yes (n=44)</td>
<td>7-11</td>
<td>Home</td>
<td>80%</td>
</tr>
<tr>
<td>Dongen-Boomsma, Vollebregt, Buitelaar, &amp; Slaats-Willemse (2014)</td>
<td>Yes (n=47)</td>
<td>5.5-7.3</td>
<td>Home</td>
<td>91%</td>
</tr>
<tr>
<td>Holmes &amp; Gathercole (2014)</td>
<td>No (n=22)</td>
<td>M=8.67</td>
<td>School</td>
<td>90%</td>
</tr>
<tr>
<td>Bigorra, Garolera, Guijarro, &amp; Hervas (2015)</td>
<td>Yes (n=65)</td>
<td>7-12</td>
<td>Home</td>
<td>94%</td>
</tr>
<tr>
<td>Soderqvist &amp; Nutley (2015)</td>
<td>Yes (n=20)</td>
<td>M=9.85</td>
<td>School</td>
<td>100%</td>
</tr>
<tr>
<td>Stevens, Gaynor, Bessette, &amp; Pearlson (2016)</td>
<td>Yes (n=18)</td>
<td>12-18</td>
<td>Home</td>
<td>100%</td>
</tr>
<tr>
<td>Hitchcock &amp; Westwell (2017)</td>
<td>No (n=54)</td>
<td>12.25</td>
<td>School</td>
<td>70%</td>
</tr>
</tbody>
</table>

Together, these findings are encouraging with respect to levels of student participation, including that of students with ADHD, when CWMT is utilized in schools.
**Near transfer.** In addition to high compliance rates, CWMT studies demonstrate improvement in working memory tasks utilized during training and an improvement on similar cognitive tasks not trained (Beck, Hanson, Puffenberger, Benninger, K., & Benninger, M., 2010; Chacko et al., 2014; Gray et al., 2012). Ample evidence has demonstrated that CWMT improves the performance for students with ADHD on tasks that require near transfer. Gray et al. (2012) tested 60 participants with ADHD between the ages of 12 and 17 and randomized the participants into experimental and control groups. The experimental group received CWMT, and the control group received the same amount of training using a computerized math training program that adapted as students mastered concepts in 10 essential skills. While parents and teachers were not blind to the conditions, they did not know the hypotheses of the researchers regarding the two programs. The WM group demonstrated a 28% and 36% greater improvement in two separate measures of working memory not specifically trained in the program. Chacko et al. (2014) stated goals were to replicate Green et al. (2012) with a “more rigorous methodology” (p. 248). The researchers used a control condition placebo that was a CWMT identical to the experimental except that tasks did not become progressively more difficult with mastery. Compared to control, they found a greater improvement on near transfer effects in WM in the active group. The experimental design, sample size, and control conditions confer validity to the conclusions reached and suggest the possibility of generalizing CWMT’s effects on WM to students with ADHD.

Further studies provided additional evidence of near transfer effects. Stevens, Gaynor, Bessette, and Pearlson (2016) hypothesized that WM training would increase and possibly normalize WM circuits in adolescents’ brains with ADHD as assessed with fMRI techniques. Their sample consisted of 18 youths (6 females, 12 males) with ADHD and a sample of 18 non-
ADHD adolescents of comparable IQ, sex, age, and SES. Researchers conducted fMRI in participants one week before and two weeks after WM training. During fMRI sessions, participants completed the Sternberg WM task, which asked them to remember locations of briefly presented stimuli. The results demonstrated that WM training produced gains in WM, and many of the frontoparietal brain regions where abnormalities were detected before training in ADHD participants were not significantly different than those of non-ADHD participants after treatment. Their findings suggest that some aspects of mental functioning normalized as a result of WM training. However, the results of Liu, Lishak, Tannock, and Wolterning (2017) conflicted with Stevens et al. (2016) and demonstrated no evidence of neural plasticity after WM training. Liu et al. (2017) separated their participants (N=88) into three groups: standard length training of 45 minutes, shortened-length training of 15 minutes, and a waitlist group to serve as the control. Following the training, participants completed the Go/Nogo task and EEG was recorded, and ERP’s were collected. However, the differences in results from Liu et al. (2017) could be a result of the use of high functioning adults with ADHD instead of the adolescents used in Stevens et al. (2016). Additionally, WM is considered a high level of processing, and as Katzir and Pare-Blagoev (2010) note, EEG is a better method for investigating low-level processing.

**Far transfer.** Despite the positive outcomes reported for near transfer effects of CWMT, the results from studies reporting on the far transfer effects are less encouraging and often conflicting.

**ADHD symptoms.** Studies in changes of ADHD symptoms following CWMT yielded conflicting results. Beck et al. (2010) sampled 52 adolescents from 7 to 17 with ADHD or other learning difficulties and examined their ADHD symptoms before and after CWMT. They found
that participants significantly improved on the parents’ reported measures of their executive function skills including (1) working memory, (2) planning/organizing, (3) inattentive behaviors, and (4) initiate after training. These improvements were still present at a four-month follow up. A limitation of the study was that there was no control group and the parents were not blind to the treatment. Gray et al. (2012) included a control group, thus improving validity over the Beck et al. (2010) study, but they also were unable to make the parents and teachers blind to the study. Students demonstrating the most improvement on the WM training tasks were observed to exhibit the greatest reduction in symptoms of inattention and hyperactivity (Gray et al., 2012). This provided further evidence that CWMT improved the symptoms of ADHD indicating credible far transfer effects. However, changing the off-task behavior of a student with ADHD does not often result in improved academic performance, which limits the potential applications for an intervention aimed at improving EFD beyond behavioral problems (Purdie, Hattie, & Carroll, 2002).

Additionally, Chacko et al. (2014) refuted Gray et al. (2012) and Beck et al. (2010) with a more robust sample size (n=85) and an improved randomized control condition with greater similarity to CWMT. They found that the CWMT active group did not show improvement in behavior as measured by parent and teacher rated ADHD symptoms, objective measures of inattention, and impulsivity. Bigorra, Garolera, Guijarro, and Hervas (2015) aimed to respond to Chacko et al. (2014) with a rigorous, randomized, double-blind, placebo-controlled, parallel-group clinical trial of CWMT. Bigorra et al. (2015) included many more measures of ADHD symptoms and a more thorough and robust statistical analysis than performed by Chacko et al. (2014). Sixty-six participants ages seven to twelve with combined-type ADHD participated in the study and were randomized to two groups. Similar to Chacko et al. (2014), the control group
utilized a CWMT that did not progress in difficulty. Results in Bigorra et al. (2015) conflicted with Chacko et al. (2014) and found that participants improved on measures of ADHD symptoms as reported by both parents and teachers with greater improvement on the scales completed by teachers. Bigorra et al. (2015) offered a possible explanation for the discrepancy in findings when they stated that the improvement index on the CWMT was greater in their study possibly due to the placebo effect as parents supported their children after each training session and provided the key outcome data on improvement in EF. The conflicting results of Chacko et al. (2014) to Beck et al. (2010), Gray et al. (2012), and Bigorra et al. (2015) demonstrate that more research is needed to address limitations in the current studies and that other factors might contribute to far transfer success or failure.

Academic performance and achievement. Research on far transfer effects of CWMT that might play a role in academic achievement report conflicting results. Training such CMWT would demonstrate far transfer if students used their improved WM to increase their performance on school tasks. Dahlin (2010) tested 57 children with ADHD at ages ranging from nine to twelve in Stockholm, Sweden. She examined students’ reading comprehension using two tests administered both pre- and post-CWMT: Progress in International Reading Literacy Study and Reading Literacy study. Dahlin (2010) found a substantial effect size improvement (d = .91) on the measure of reading comprehension. Soderqvist and Nutley (2015) extended the research on the far transfer effects of academic achievement by matching 20 participants at an average age of 9.85 to a control group of 22 students that did not receive the training. Measures of academic achievement were reading comprehension and math performance on the Swedish National Standardized Tests administered in the spring of third grade. The results demonstrated improvement on the tests for the CWMT group two years following training. The results should
be interpreted with some caution, however, because Pearson Clinical Assessment makes CWMT and they funded the study and employed the principal investigator.

Despite the promising results from Dahlin (2010) and Soderqvist and Nutley (2015), other studies did not confirm their results. Hitchcock and Westwell (2017) studied a population of primary school students with a mean age of approximately 12 years-old in South Australia. The controlled study included 148 participants with no exclusion criteria. The researchers used CWMT program as the active condition, and the control was an unscaffolded version of CWMT discussed in other studies. In addition to measures of far transfer, they hypothesized that task-unrelated thoughts would mediate the impact of CWMT. They found that the active training condition did not demonstrate a positive impact on everyday school functioning. They accepted the null hypothesis that CWMT active condition produced no differences in measures of task-related attention, reading, and mathematics compared to the control. For comparison purposes, a limitation of the study is that they used a normal population of students and thus the results may not transfer to a population of ADHD students with deficits in WM. Van der Donk et al. (2015), however, supported the previous study’s findings with a randomized control study in a population of ADHD students. Their study differed from previous CWMT far transfer studies with respect to the measures of academics and a control condition called “Paying Attention in Class” which was a curriculum developed by the researchers aimed at teaching students EF skills for the same amount of time as CWMT. They included word reading fluency as a measure of academic performance and teacher reported behavior in class. The study found no measurable improvement on verbal WM, measures of attention, parent ratings of ADHD, executive function, and academic performance compared to the control.
**Summary evaluation of CWMT.** CWMT is a possible option as an intervention for students with ADHD in high schools because studies demonstrated that compliance rates equaled or surpassed those found in a laboratory setting with a range of 70% and 100% (Dahlin, 2011; Gray et al., 2012; Hitchcock & Westwell, 2011; Soderqvist & Nutley, 2015). Additionally, CWMT studies demonstrated improvement in working memory tasks utilized during training and an improvement on similar cognitive tasks not trained (Beck et al., 2010; Chacko et al., 2014; Gray et al., 2012). However, studies on the impact of CWMT on ADHD symptoms, academic performance, and achievement report conflicting results and the most rigorous studies with large sample sizes and adequate controls demonstrated no significant impact (Beck et al., 2010; Bigorra et al., 2015; Chacko et al., 2014; Dahlin, 2011; Gray et al., 2012; Hitchcock & Westwell, 2017; Soderqvist & Nutley, 2015; van der Donk et al., 2015).

**Mindfulness training.** Recently, techniques aimed at improving mindfulness have garnered increased consideration from researchers as a potential tool for increasing attention and improving working memory. According to Buttle (2011), most mindfulness techniques are based on the non-theistic Buddhist traditions that date back thousands of years. He states it is a broad term, and people apply many different techniques to foster mindfulness making it difficult to define fully. Generally, mindfulness is defined as bringing awareness to the present through the use of a meditative technique (Buttle, 2011). Most mindfulness programs incorporate a focus on (1) the current moment, (2) a heightened awareness, (3) a focused attention on something such as an idol, (4) controlled breathing, and (5) practicing self-regulation by returning focus when the mind wanders (Buttle, 2011).

Cognitive definitions of mindfulness and executive function (EF) clearly overlap, thus offering mindfulness training as an intriguing possible intervention for those that suffer from
cognitive deficits in EF. Processes associated with EF include inhibition, shifting attention between cognitive tasks, and utilizing WM, all with the purpose of achieving a goal (Georgiou & Das, 2016). These goals might include normal daily activities such as deciding what to eat for breakfast to more complex cognitive tasks associated with school such as listening to the instructions of a teacher for a future assignment. Barkley (1997) defined inhibition as the ability to withhold a response, delay responding, stop a response, and resist distraction during a cognitive event. Mindfulness and its emphasis on focused attention and self-regulation appear to engage the cognitive skill of inhibition. Much mindfulness training also requires the practitioner to visualize relaxing places such as a beach and often includes repetitive phonological recitation (Buttle, 2011). Working memory is involved in the storage, rehearsal, processing, maintenance, and manipulation of temporarily held phonological and visuospatial information (Baddeley, 2007). Based on these similarities in function, it appears that mindfulness may be an effective form of training for students that suffer from EF deficits in attention and WM.

Taren et al. (2017) provided support to this theory in their randomized controlled trial of the impact of mindfulness on areas of the brain known to be involved in EF. Utilizing fMRI on 35 stressed job seekers randomly assigned to a mindfulness training group and waitlist control, they found that an intensive three-day mindfulness training program during a residential retreat increased resting state functional connectivity (rsFC) between the dorsolateral prefrontal cortex (dLPC) and dorsal network. The dLPC is an important hub in the executive control network, and the dorsal networks are known for cognitive control. The implications of the brain imaging demonstrate that mindfulness training may improve EF of healthy adults compared to a control that does not complete the training. However, it is not known if these results will generalize to adolescents or impaired groups such as students with ADHD.
**Mindfulness and working memory.** Research on the links between mindfulness training and cognitive measures of EF is in its infancy, and studies reported so far include a variety of research participants, different types of mindfulness training, and varying measures of EF. In her comprehensive review of research pertaining to mindfulness and executive function, Gallant (2016) concluded that mindfulness training imparts the most benefit to the inhibitory subcomponent of EF. Given that students with ADHD often exhibit deficits in inhibition, she states that it offers promise as an intervention for people with the disability. As explained in chapter one, however, Kofler et al. (2014) demonstrated that working memory and not inhibition was the primary factor in EFD of ADHD students. Inhibition is often used synonymously with attention because one must be able to inhibit unnecessary stimuli to pay attention. Working memory impairment is the basis of EFD for many students with ADHD and contributes to lapses of attention which impair students’ ability to perform academically (Kofler et al., 2014). Therefore, studies need to demonstrate that mindfulness improves attention through improvement in WM.

Several studies demonstrated some impact of increased mindfulness on near transfer effects, presumably via changes in working memory, but the results do not provide enough evidence for application in a school setting (Van Vugt & Jha, 2011; Quach, Mano, & Alexander, 2016). Van Vugt and Jha (2011) investigated an intensive month-long mindfulness training regimen conducted with experienced practitioners and compared its impact on a delayed recognition working memory task to that of an age and education matched control group. The 29 participants aged 29-70 went to a retreat and practiced Buddhist Sathipattana Sutra for ten to twelve hours daily. The pre- and post-tests of WM confirmed that the mindfulness trained participants demonstrated improved WM. While the results are promising for mindfulness
improving WM, they do not offer external validity to high school students with ADHD and the intervention is not realistic for a school setting given the intensity and duration of the training. Additionally, the confounding variable of motivation may have influenced the results. The group of mindfulness trained participants spent a month and many hours of hard work and thus may have wanted to confirm that it was worth it.

Quach, Mano, and Alexander (2016) addressed several of the limitations of the Van Vugt and Jha (2011) with a clinical trial of adolescents conducted in a junior high school in California. Researchers randomly assigned students to one of three conditions implemented during their physical education classes for four weeks: mindfulness meditation, hatha yoga, and a waitlist control. Students were asked to respond to computer-based measures of WM on the Automated Operation Span (AOSPAN) task. The measure AOSPAN is a widely used measure of WM with high internal consistency (α = .78) and good test-retest reliability. A sample of 178 participants demonstrated that the mindfulness group significantly increased their WM scores compared to the yoga and waitlist control groups. The large sample size, control group, and age of the participants offer promise for mindfulness as an intervention for high school students with ADHD and WM deficits. However, it is still not known if the results will generalize to the ADHD sub-population of adolescents as the Quach, Mano, and Alexander (2016) study did not differentiate between typically developing and learning-disabled students.

**Summary evaluation of mindfulness training.** EF deficits include areas such as attention and inhibition which are the same areas mindfulness meditation intend to train. Quach et al. (2016) demonstrated that it is possible to successfully include mindfulness in school curricula. In their studies, Van Vugt and Jha (2011) and Quach et al. (2016) demonstrated near transfer effects of mindfulness training on performance measures of WM demonstrating some
potential promise for ADHD students. However, they did not address far transfer effects of academic achievement and performance. Further studies need to track the long-term academic outcomes of ADHD students that received mindfulness training to justify the human and financial investment of mindfulness training for educational improvement. Therefore, other strategies that lessen the impact of extrinsic cognitive load might be more appropriate at this stage of research.

**Cognitive load reduction.** Cognitive load reduction strategies provide teachers with methods to reduce the impact that WM deficits have on student learning and performance by lessening the extrinsic cognitive load often imposed by instructional strategies (Merrienboer & Sweller, 2010). Many students with ADHD might benefit from cognitive load reduction due to (1) the prevalence of WM problems, (2) the negative impact of WM deficits in their education (Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Mattfeld et al., 2016; Wilcutt et al., 2005), and (3) the lack of accommodations in IEP that address this deficit (Lewandowski et al., 2014; Lewandowski et al., 2007; Lovett & Leja, 2015; Murray et al., 2014; Spiel et al., 2014). Sweller (2016) defines cognitive load reduction as any process that reduces the number of elements of information imposed on working memory. He states that cognitive load effects lessen when the instructional procedures reduce the number of elements that require information processing by the test-taker. When a student must attend to multiple pieces of information and integrate them so that they understand the directions, they are splitting their attention, and this places a higher demand on WM (Sweller, 2016). Decades of research on cognitive load reduction identified fifteen strategies for educators to employ to reduce it including worked examples (van Merrienboer & Sweller, 2010).
Worked examples. The most widely studied cognitive load reduction strategy is the use of worked examples (Sweller, 2006). This method requires the student to study a solution to a problem instead of solving the actual problem (Pawley, Ayres, Cooper, & Sweller, 2005). Booth, Cooper, Huyghe, Koedinger, and Paré-Blagoev (2015) tested the use of worked examples in Algebra instruction to reduce the achievement gap between Caucasian and minority students. They stated that worked examples are a method to reduce the cognitive load of students by allowing them to learn the steps of the problem instead of holding long strings of steps in WM while trying to solve the problem. In a randomized control trial (RCT) with a pre and post-test design, 26 students received the AlgebraByExample assignments, and 25 students in the control group received assignments without the worked examples. The students that received the AlgebraByExample curriculum improved more than the controls. Additionally, the achievement gap which was present at pre-test disappeared at post-test. This initial study resulted in a larger three-year double-unit study in six school districts by the same authors. They randomized individual classrooms with each teacher having a treatment classroom and control to reduce threats to internal validity due to teacher variability. This larger study included measures of moderating variables such as students’ motivation, conceptual, and procedural knowledge. They created an Algebra workbook with 42 assignments, and the control group had traditional assignments. They collected the workbooks to ensure treatment fidelity and the results demonstrated that students on the lower end of the performance pre-test measures received the greatest benefit from the worked examples curriculum by outperforming comparable controls by 10%. Furthermore, the treatment group outperformed the control group by four points with half the amount of practice (Booth et al., 2015). The study adds to decades of research bolstering a strong theoretical basis for cognitive load reduction strategies lessening the impact of WM
deficits (Booth et al., 2015; Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). Additionally, the significantly improved results for lower end performers compared to higher end performers garners further support for its use with ADHD students that academically underperform.

Kyun, Kalyuga, and Sweller (2013) added to the research by differentiating between problems that are well-defined and ill-defined. Much of the previous research involved well-defined problems in math that had technical solutions (Kyun et al., 2013). They wanted to know if the worked example effect could extend to ill-defined problems such as essays in history, literature, and social studies. They conducted three successive experiments with college students in Korea. The results of the three studies demonstrated that the worked example groups performed better on retention posttests, but there were no significant differences in near and far transfer. They measured near and far transfer with essay questions similar to the worked examples, and essays that were different from the worked examples. One finding from their study that is confirmed by other research is the negative correlation between low knowledge learners and worked examples interventions (Pachman, Sweller, & Kalyuga, 2014). The population of Korean college students, however, may not generalize to high school students with ADHD and EF deficits in Pennsylvania.

Schwaighofer, Buhner, and Fischer (2016) studied EF deficits as a moderating variable of the worked example effect in solving statistics problems. They used a randomized controlled experiment with German undergraduate participants (n=76) with the experimental group receiving worked examples and a control group that solved the same problems without the use of worked examples. Before the experiment, participants received a battery of WM assessments, shifting assessments, and fluid intelligence measures. They found that WM had no moderating
influence on the effect of worked examples. While this finding may not generalize to high school students in the United States, it does cast doubt on the construct validity of worked examples helping students with WM deficits such as high school students with ADHD.

Nevertheless, the researchers suggested a possible hypothesis for not detecting moderating effects of WM: the participants learned the solution steps through worked examples, and they had to keep them in WM while solving the subsequent problems. Therefore, participants may not have realized any benefits because their WM was still under too much cognitive load. Newell and Simon (1972) demonstrated that external memory aids reduce the cognitive load on WM. It is possible that without a memory aid of the worked example cognitive load on the test-takers was increased.

**Summary evaluation of cognitive load reduction strategies.** Decades of research bolster a strong theoretical basis for cognitive load reduction strategies lessening the impact of WM deficits (Booth et al., 2015; Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). Much of the early research demonstrated that instruction utilizing worked examples could help students in mathematical problems solving (Booth et al., 2015; Cooper & Sweller, 1987; Paas & van Merrienboer, 1994; Sweller & Cooper, 1985). Recent research differentiated the types of students that most benefitted from cognitive load reductions strategies and determined that low knowledge learners received most of the benefit (Pachman et al., 2015). However, these studies did not distinguish if ADHD students would be in the category of low knowledge learners. Therefore, it is not known if the results would generalize to this sub-population. ADHD students have EF deficits, and Schwaighofer et al. (2016) demonstrated that EF deficits were not a moderating variable for the effects of worked examples. Additionally, Kyun et al. (2013) did not
find that the worked example effect extended to ill-defined problems in subject areas such as literature, history, or social studies. Given that much of academic performance is measured with these areas factoring heavily, the study casts doubt on a worked examples approach to improve overall academic performance in ADHD students. In addition, most studies of worked examples focus on the learning of subject-specific content. It is not known if the strategy can be used by students to learn a skill that will help them perform any content specific task or the impact it may have on students with ADHD.

Conclusions

The theory of cognitive architecture proposed by Sweller, van Merrienboer, and Paas (1998) supports the idea that there are two ways to help students with deficits in WM. The first is to make attentional processes automatic through routinizing and repetition of the skill thereby limiting the intrinsic cognitive load. The second approach is to present tasks in a way that minimizes the amount of stress placed on WM which reduces the extrinsic cognitive load (Sweller, van Merrienboer, & Paas 1998). CWMT and mindfulness training utilize the first approach by rehearsal of EF skills such as WM and attention, whereas cognitive load reduction utilizes the second by limiting the amount of information students must contain and manipulate during instruction. Studies of CWMT demonstrated high compliance rates in school and at home with improved scores in measures of WM (Beck et al., 2010; Chacko et al., 2014; Dahlin, 2011; Gray et al., 2012; Hitchcock & Westwell, 2011; Soderqvist & Nutley, 2015). However, studies on the impact of CWMT on ADHD symptoms, academic performance, and achievement greatly conflict and the most rigorous studies with large sample sizes and adequate controls demonstrated no significant impact (Beck et al., 2010; Bigorra et al., 2015; Chacko et al., 2014; Dahlin, 2011; Gray et al., 2012; Hitchcock & Westwell, 2017; Soderqvist & Nutley, 2015; van
der Donk et al., 2015). Results from mindfulness training are similar to those of CWMT with some evidence of near transfer to measures of WM, but little evidence supports improved academic achievement and performance (van Vugt & Jha, 2011; Quach et al., 2016). Unlike CWMT, the researchers of most mindfulness studies do not distinguish and test the sub-population of students with ADHD. Therefore, it is difficult to determine if the effects will transfer to high school students with ADHD and WM deficits.

Cognitive load reduction strategies demonstrated improved academic performance for those that suffer from WM deficits (Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). However, like the studies for mindfulness, researchers in cognitive load reduction methodologies have yet to test ADHD as a moderating variable. Additionally, the most researched cognitive load reduction strategy, worked examples, helps low knowledge learners in well-defined problems often presented in math and science classes (Kyun et al., 2013). Those measures are a few of the overall output of school performance and achievement but do not address many other areas such as learning and performance in social studies and language arts classes.

The lack of evidence for the long-term transfer of CWMT and mindfulness to the academic improvement of ADHD students does not lend support for its use as an intervention at this time (Beck et al., 2010; Bigorra et al., 2015; Chacko et al., 2014; Dahlin, 2011; Gray et al., 2012; Hitchcock & Westwell, 2017; Soderqvist & Nutley, 2015; van der Donk et al., 2015). Cognitive load reduction strategies are a viable alternative as they have evidence of improving academic success for students with WM deficits and low-knowledge learners (Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). Therefore, chapter four will propose an intervention study
aimed at improving the academic performance of ADHD students at Nest View High School by (1) teaching the students a cognitive load reduction testing strategy, (2) providing worked examples to learn the strategy, and (3) allowing the students the use of a memory aid of the strategy during testing. I will discuss the decision to employ a single-subject multiple baseline mixed-methods research design (QUAN > qual) and details of the study.
Chapter 4

Existing research on interventions that address the significant academic underachievement and performance of high school students with ADHD is insufficient (Barkley, 1997; Loe and Feldman, 2007). Many students with ADHD suffer WM deficits which impair their ability to perform in the academic environment (Bull & Scerif, 2001; Friedman et al., 2016; Gathercole et al., 2016; Kofler et al., 2014; Mattfeld et al., 2016; Wilcutt et al., 2005). The needs assessment findings in the spring of 2016 demonstrated that the problem exists at Nest View High School with most of the sampled students demonstrating low academic achievement, performance, and WM deficits. As discussed in Chapter 3, the most widely studied strategy with evidence of success for students with WM deficits are cognitive load reduction strategies (Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). The current study introduced a cognitive load reduction program (CLRP) for high school students with ADHD to reduce the negative effects of WM deficits on their academic performance.

Purpose of the Study

The purpose of this study was to investigate the extent to which a CLRP can improve the academic performance of high school students with ADHD. The following quantitative, qualitative, and mixed methods research questions directed the study.

RQ1: To what extent are high school students with ADHD completing the Cognitive Load Reduction Worked Examples intervention activities and utilizing the strategy as intended during testing?
RQ2: To what extent does learning a cognitive load reduction strategy from worked examples and employing the use of a memory aid during testing lead to the increased academic performance of high school students with ADHD?

RQ3: What are ADHD high school student perceptions of the impact of extrinsic cognitive load on test performance?

RQ4: How do ADHD students believe the CLRP impacted cognitive load during testing and in the classroom?

RQ5: To what extent do the ADHD student perceptions confirm the test score data?

Utilizing the same definitions and rationale discussed in the needs assessment, academic achievement is the ability to learn and apply knowledge on standardized tests and academic performance as the levels of accomplishment in regular education classes as demonstrated by scores on homework, classwork, quizzes, projects, and course exams. Standardized tests in Pennsylvania are provided annually and only to some students, i.e. those that do not opt out of the testing. Additionally, the reports of the scores do not arrive promptly; often the following year. As result of the difficulty of obtaining timely and accurate standardized test data for all participants, improving academic performance instead of academic achievement is the goal of the current study. The research design described below tested the hypothesis that learning a cognitive load reduction strategy from worked examples and employing the strategy with the use of a memory aid during testing will result in improved academic performance for high school students with ADHD.

**Research Design**

The current study utilized a single-subject multiple baseline mixed methods embedded research design (QUAN > qual) to answer the questions above. Randomized clinical trials
RCT) are the gold standard of research methodology. However, they are often not possible in experimental research within the field of special education because of the variability of the participants and contexts (Odom et al., 2004). Therefore, Horner et al., (2005) advocate the use of single-subject research when studying the special education population, including students with ADHD. Single-subject research differs from case studies because there is an experimental control to reduce threats to internal validity. A study typically includes three to eight participants with each participant serving as their own control with baseline measurements of the dependent variable collected before the intervention. A key component is the continual and frequent measurement of the dependent variable before and after the intervention (Horner et al., 2005).

Several experimental methods are available for obtaining this level of control, and for the present study, the multiple baseline design across participants was the chosen method. In this design, the researcher obtains baseline data from each participant and introduces the intervention at three or more different times, demonstrating an effect at each point, and follows all of the participants to the same endpoint (Horner et al., 2005; Shadish, Hedges, Horner, & Odom, 2015). To accomplish the multiple baseline design for the current study, Participant 1 received the training after 14 weeks of baseline measurement, Participant 2 after fifteen weeks, and Participant 5 after 21 weeks. The typical independent variable in a single-subject design is an intervention, which in the current study was a presentation to students of a cognitive load reduction strategy from worked examples and application of the strategy with the use of a memory aid during testing.

Additionally, a mixed methods approach to data collection strengthened the current study by adding qualitative data about the treatment integrity (Collins, Onwuegbuzie, & Sutton, 2006). According to Rossi, Lipsey, and Freeman (2004), there are five domains for assessing a program
and the qualitative data from my study focused on two of them: providing a supportive role to help evaluate the program’s design and implementation of the strategy by the students and school district staff. Further qualitative data about participants’ perceptions will provide information helping confirm the quantitative results.

Logic Model

The logic model below (Figure 4) helps identify the assumptions, inputs, and activities that lead to the eventual intended outcomes from the single-subject multiple baseline mixed methods embedded experimental design. The needed inputs included time for the researcher to create the worked examples, time for the completion of the CLRP activities, and administrative support. The main activities were designed to include three to eight students with ADHD and an Individualized Education Program (IEP) learning the CLRP in their special education classrooms or on their own time if they had not received specialized instruction as part of their IEP. The intended outputs from the learning experience were the use of the strategy in class and on subsequent tests.

Figure 4

*Logic Model of an ADHD Intervention*
Leviton and Lipsey (2007) stated that it is necessary for a theory of treatment to clearly and as specifically as possible express the expected outcomes. As a result of the CLRP, extrinsic cognitive load on tests will be reduced resulting in improved performance. This study defines academic performance as the levels of accomplishment in regular education classes as demonstrated by scores on homework, classwork, quizzes, projects, and course exams. Core class (social studies, language arts, math, and science) test scores served as the short term outcome measure as they provide the most opportunity for use of the strategy and students take

---

**Figure 4.** A logic model of the assumptions, inputs, activities, and outputs regarding an intervention aimed at improving the academic outcomes of students with ADHD.

---

External Factors:
- Lack of consent, lack of participation, comorbidity of ADHD and other learning disorders, extent and magnitude of WM deficits, amount of tests administered in classes, types of questions asked and degree of extrinsic cognitive load

---

Long-term Outcomes:
- Change IEP to include cognitive load reduction in conjunction with extended time
- Increased graduation rates
- Increased college acceptance rates

---

Medium-term Outcomes:
- Student understanding of CLRP
- Improved history test scores
- Improved learning during regular education classes
- Reduced extrinsic cognitive load

---

Short-term Outcomes:
- Improved performance as measured by grade point average (GPA) and class rank

---

Inputs:
- Class time in the special education classes
- Support form the upper levels of administration to make it required curricula
- Online Schoology learning modules
- Personal time to create the worked examples

---

Activities:
- Three to eight students with ADHD and an IEP
- Five cognitive load reduction online Schoology learning modules with instruction, worked examples, and practice in special education classes, study halls, or at home
- Students may use a memory aid of the strategy during testing as an accommodation
- Use of the strategy by ADHD students while testing
- Use of the strategy by ADHD students with worked examples during special education classes
- Worked examples learning modules
- Student engagement

---

Outputs:
- Improved performance as measured by grade point average (GPA) and class rank
- Reduced extrinsic cognitive load

---

Assumptions:
- Students with ADHD have WM deficits
- Accommodations are not effective
- Needs assessment confirmed assumptions above, but with a limited sample size
frequent unit tests. I used marking period grades in the participants’ core classes as key indicators of academic performance and medium-term outcomes as they are dependent on improved test scores in the core classes.

Improved academic performance, as defined above, can contribute to significant improvements in long term outcomes of students with ADHD. Breland (2002) conducted a national survey of 1,644 colleges and reported that GPA and class rank were the most important factors in college admission between 1979 and 2000. Also, students’ course grades, GPA, and class rank are better predictors of high school and college graduation, and many other longer-term life outcomes, than standardized test scores (Allensworth & Easton, 2007; Roderick, Nagaoka, & Allensworth, 2006). Thus, the long term outcomes of a CLRP for high school students with ADHD include increased graduation rates and college admission.

**Process Evaluation**

To determine the extent to which ADHD students completed the activity as intended, I explained the context, measured the reach, dose, and fidelity of the program implementation (Linnan & Steckler, 2002). The CLRP activities included five, twenty-minute online lessons created by the researcher. Each online activity included instruction, worked examples, and practice. The researcher created the online lessons to ensure each one was carried out as intended and prevent teacher variation of instruction. Students completed the lessons using an online course management system called Schoology. The case manager or special education teacher was primarily responsible for editing the settings of the assignment and creating a due date on the Schoology course page for the CLRP lessons during the intervention period. Students involved in the study completed five lessons during their specialized instruction classes during the second nine-week marking period or on their own time if they do not receive
specialized instruction. To increase the likelihood of this happening, the teachers reminded the students to complete the lessons during their individualized instruction classes or during one-to-one meeting times. The two process measures were: 1) teacher feedback and 2) responses from interview questions with the research participants.

**Context.** The context for the current program existed in three spaces: the specialized instruction classroom, the testing room, and Schoology (the online course management system). Most special education students went to a smaller classroom in the school with a special education teacher. The classes were 47-minutes in length and met twice a week for the duration of the school year. Additionally, there was a dedicated testing room with a teacher on duty during each period of the day. The Schoology classroom was embedded in the online course management system, and student schedules were loaded into the program. Each student had a school issued laptop and accessed Schoology at any time from the district Wi-Fi signal. A drop-down menu within Schoology allowed students to access each class. Each course design was at the discretion of the teacher. Once a teacher made an assignment within the course, however, it appears on the students’ upcoming events menu, and on the calendar. Students accessed the worked examples activities in any of the three locations in the Schoology class.

**Fidelity of implementation: Participant responsiveness.** Participant responsiveness has two key components which are involvement and engagement in the program (Dusenbury, Brannigan, Falco, & Hansen, 2003). For the current study, involvement was assessed as the successful completion of the online learning modules by the student participants and the use of the strategy on tests when applicable. I used the qualitative data gathered from the focus group questions to provide evidence of engagement, use of the strategy during tests, and access to the memory aid as a testing accommodation.
**Fidelity of dose.** According to Dusenbury et al. (2003), measuring dosage may be necessary when non-research personnel are delivering the intervention. Special education teachers implemented the CLRP during the specialized instruction time with the use of the pre-prepared computer modules, or students completed the activities on their own time. Teacher feedback and participant interviews served as the measure of dose. Students were expected to complete all five training sessions as part of the study.

**Outcome Evaluation**

As discussed above, the single-subject multiple baseline mixed-methods design was the methodology for the current study. To accomplish the multiple baseline design, Participant 1 received the training after 14 weeks of baseline measurement, Participant 2 after fifteen weeks, and Participant 5 after 21 weeks. The primary outcome indicator was student test scores on unit tests. Each student had four core subject classes with a test estimated to occur every two weeks. This evidence sufficiently met the requirements established for single-subject design with a minimum of five data points for the baseline and post intervention phase. Additionally, I used course marking period grades as additional key indicators of academic performance.

Students at the high school are required to complete 23.8 credits to graduate with each full year class counting as 1.0 credit. Grades and quality points for each class are calculated with the grading system below in Table 7 (Course Selection Guide, 2017). Each 1.0 credit course consists of many different assignments, quizzes, and tests that combine for the final grade in the course. Therefore, course grades and level of enrollment made it a good indicator of content validity as defined above.

Table 7

*Grading System*
## Threats to internal validity

A strength of a single-subject design is that it controls for most threats to internal validity (Horner et al., 2005; Shadish et al., 2015). The counterfactual is similar in theory to that of RCT because the baseline serves as the outcome measurement if the intervention never happened. It is not a perfect inference due to the elapse of time. Therefore, a weakness of single-subject design is the threat to internal validity of maturation (Shadish et al., 2015). One method to control for maturation is to include participants of roughly the same age (Shadish et al., 2002) which the current study recruited.

Despite this weakness, Shadish et al. (2015) stated that single-subject design rules out most threats to internal validity because the research probes the effect of the intervention at different points across multiple subjects. They claim it is similar to interrupted time series designs sometimes used in RCT, but stronger because there are more opportunities for experimenter control. Therefore, they claim that single-subject design studies tend to create stronger inferences than interrupted time series RCT (Shadish et al., 2015).
**Threats to external validity.** On the surface, it appears that the most significant weakness for single-subject designs is their inability to generalize to larger populations due to the small, and potentially unrepresentative, sample size. While this concern has merit, Shadish et al. (2015) discuss that the fear is overstated. Single-subject design at times can provide better generalizations than RCT when the researcher provides information about the context and participants. They believe that random sampling rarely contains all possible cases of treatment across settings, dosage, providers, and variations in the measurements of the observed outcomes. Further, they outline five principles that allow for generalization in single-subject research, and most of them are satisfied when the researcher describes the context and participants (Shadish et al., 2015).

**Methods**

**Participants.** As followed in the needs assessment, the population for the present study were high school students (grades 9-12) recruited at a large suburban school district in Pennsylvania with an IEP that lists “Other Health Impairment” as their primary or secondary disability.

The population of students at Nest View High School with ADHD and an IEP is small (n = 40). The Superintendent of Schools sent the recruitment materials via electronic mail to the parents of students in the population with a link to an online consent. After the initial recruitment phase, the sample was beneath the target number of three to eight participants needed for a single-subject design (n = 2). In an attempt to increase the sample size, I expanded recruitment to a larger population of two additional high schools within the school district. After the additional recruitment efforts, the number of parents consenting to participate (n = 12) exceeded the target range of three to eight.
Several factors contributed to subsequent participant attrition, however. The first was that two participants would not sign the assent form because they believed participation would require additional work beyond their current course load. Three participants never received the assent form from their case manager. One case manager did not feel it was within her job responsibilities and thus would not assist in the delivery of the intervention. The director of pupil services could not identify one parent from the consent form because of a possibly misspelled name, and one participant intended to participate, but never signed the assent form. Their IEP indicated that one of their academic goals was assignment completion, indicating that this was a weakness they were working to improve and may be the reason they never signed the form. Thus, from the original 12 parents that signed the consent, four participants enrolled in the study.

The final four participants met the criteria established for this study and none of them met the criteria for exclusion. All four participants were 16 years old and had an IEP with the classification of Other Health Impairment as their primary disability due to ADHD. None of the participants had a secondary disability listed on the IEP. Barkley (2014) in his widely-referenced book about ADHD stated that comorbidity rates of ADHD and learning disabled (LD) ranged from 33% to 45% depending on the definition used for LD. Similarly, DuPaul, Gormley, and Laracy (2012) reviewed articles on ADHD and LD between the years 2001 and 2011 to develop estimates of the rates of comorbidity. After reviewing 17 studies, they determined the estimated range was 24% to 38%. While Barkley (2014) and DuPaul et al. (2013) do not agree on a precise estimate, the evidence still supports the notion that a high percentage of students with ADHD also have an LD. That none of the students in the present study had any other learning disabilities eliminated the possibility of comorbidity as a moderating variable.
In addition to their IEP for Other Health Impairment, the participants in the study fit the targeted population as they all demonstrated areas of academic underperformance and underachievement. At the time of the study, the school district recognized four levels of classes and assigned higher quality points for calculating grade point average in the higher levels. The levels from highest to lowest were advanced placement, accelerated honors, honors, and college/career prep. Three of the four participants were in the lowest level classes for all four core classes. Participant 1 had one honors level class and three of the lowest level. For comparison, an 80% grade in a college/career prep class was the equivalent of a failing grade in an advanced placement class in quality points (Table 7). Additionally, state Keystone scores reported on the IEP of two of the participants indicated that they were marked Basic in all four exams. A Basic score is considered failing and is the second lowest score one can receive on the state tests.

An estimated 33% to 60% of ADHD students have deficits in working memory, which are typically not addressed as part of their IEP (Biederman et al., 2004; Lambek et al., 2011). Schreiber et al. (2014) stated that working memory deficits accounted for almost one quarter of the variation in learning problems for students with ADHD, while Gerst et al. (2015) found that working memory was positively correlated with reading scores for students with ADHD. Three of the four participants in the present study had deficits in WM confirming Friedman et al. (2013) research (Table 8).

Table 8

<table>
<thead>
<tr>
<th>Participants Working Memory Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM Score</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Participant 1</td>
</tr>
<tr>
<td>Participant 2</td>
</tr>
<tr>
<td>Participant 3</td>
</tr>
</tbody>
</table>
ADHD students without WM deficits, such as Participant 3, may not realize the same effects from cognitive load reduction.

**Exclusions.** As discussed above, any student with ADHD minus an IEP were not included in the study because school district personnel do not know the diagnosis. Other exclusions from the study were students with an IEP for “Other Health Impairment” if they received that classification for a reason other than ADHD as verified through the parent survey.

**Instruments and materials.** The study required the use of quantitative and qualitative instruments to measure moderating variables, academic performance, the fidelity of implementation, and descriptions of the context. Additionally, the intervention utilized researcher-created instructional materials and testing aids.

**Working memory.** Working memory (WM) is the storage, rehearsal, processing, maintenance, and manipulation of temporarily held phonological and visuospatial information (Baddeley, 2003). WM deficits are a bottleneck for more advanced cognitive processes because information must be held in WM before being utilized for other more advanced thinking such as problem solving and learning new facts or skills (Nutley & Soderqvist, 2017). The level of WM deficit likely served as a moderating variable between the cognitive load reduction program and the academic performance of students with ADHD.

The indicator of WM deficits utilized for this study were the scores students with ADHD obtained on the Working Memory Subtests on the Weschler Intelligence Scale for Children Fifth Edition (WISC-V) or any other version of the WISC test administered by a licensed psychologist. The Working Memory Subtests from the WISC are typically listed on a students’ Evaluation Report or Reevaluation Report and are standardized. The WISC, WAIS, and their
subtests are well-established measures of WM. Wechsler (2003) reported an $r = .83$ for test-retest reliability of the WM subtests, and internal consistency in the adequate range ($\alpha = .74$).

**Academic performance.** I utilized test scores and grades in the core courses as measures of academic performance. Unit test scores in the core subject classes of science, math, social studies, and language arts served as the short-term outcome measure of academic performance. Teachers of those subjects assigned, graded, and recorded the test scores. The school district maintained a server and PowerSchool software program that housed the records of student performance entered by the teachers. Test scores served as a mediating variable for academic performance as it is one of the primary methods teachers used to assess students. So, as defined above, academic performance was measured by the level of accomplishment attained in regular education classes as demonstrated by scores on homework, classwork, quizzes, projects, and course exams.

**Fidelity of implementation.** The fidelity of implementation was measured by the completion of the online worked examples training sessions by the participants. The researcher obtained the qualitative data from structured student interviews. In addition, the interviews added descriptions of participant responsiveness, understanding of the CLRP, use of it, and perceived benefit.

**Instructional materials.** I supplied the CLRP online lessons to the students via Schoology and provided the memory aid to the case managers and special education teachers assigned by the school district to each student.

**CLRP online lessons.** Recently, Nest View School District adopted an executive functions curriculum framework for the study skills classes taught to students with an IEP. The curriculum follows the *Executive Functions: A Blueprint for Success* guidebook by the Rush
NeuroBehavioral Center (Bozeday, Gidaspow, & Allen, 2016). The fourth unit, Study Strategies, included a worksheet on how to break down directions (Executive Functions, p. 31). The CLRP builds on the strategies described in the Executive Functions guidebook and demonstrated how students can use the same strategy to break down the components of a test question.

In total, students completed five online lessons on the Schoology course management system. Each lesson utilized worked examples to demonstrate the methodology. As discussed in chapter three, use of worked examples is expected to reduce the extrinsic cognitive load placed on WM and has demonstrated success in mathematical problem solving and in helping low knowledge learners (Booth et al., 2015; Cooper & Sweller, 1987; Paas & van Merrienboer, 1994; Sweller & Cooper, 1985). This method requires the student to study a solution to a problem instead of solving the actual problem (Pawley, Ayres, Cooper, & Sweller, 2005). The instructional materials included sample tests, directions, and questions from ninth-grade core subject classes in language arts, social studies, math, and science (Appendix F). Only test questions from the first nine-week marking period were used as examples because these are questions the students would have seen previous to the intervention. The worked examples in each lesson demonstrated how to use the CLRP with techniques which include (1) circling direction words, (2) underlining key words, (3) crossing out distractors, and (4) defining key vocabulary in the margins (See Appendix F).

Memory aid. Remembering how to use the CLRP during a test would require the use of the central executive in WM to access the strategy from long-term memory when applicable which could further stress WM. Newell and Simon (1972) demonstrated that external memory aids reduce the cognitive load on WM. Therefore, the case managers and special education
teachers assigned to each student by the district were to supply each participant in the study with a paper copy memory aid of the CLRP strategy for their reference while taking unit tests (Appendix G). Additionally, the case manager and special education teacher should have supplied a digital copy on Schoology with the rest of the materials.

**Procedure**

**Participant recruitment.** Recruitment and retention of participants is a significant challenge for many studies (Cook, Godiwalla, Brooks, Powers, & John, 2010) including the current one. Thus, a major advantage of using a single-subject design is that it requires far fewer participants than a RCT. The current study utilized the same recruitment methods as those employed in the Needs Assessment Study.

The Superintendent of Schools approved the selection of participants and document collection, and the Director of Pupil Services and the Database Specialist identified the students at the three high schools with an IEP for “Other Health Impairment.” Upon identifying the potential participants, the Superintendent of Schools sent an email introduction with the cover letter attached (See Appendix H). Additionally, the email contained a link to the consent/assent form (Appendix I) on the Johns Hopkins University Qualtrics program and the option to respond “I consent to participate in the study.”

Attrition was not a significant concern at the start of the study but became more of a problem as it progressed. Sections in Chapter 5 discuss the problem in more detail. The researcher did not offer any incentives for participation in the program.

**Intervention.** The typical independent variable in a single-subject design is an intervention, which in the current study was the cognitive load reduction program (CLRP). As discussed in the previous chapter, cognitive load is a significant problem for many students with
ADHD, but can be lessened by applying instructional strategies (Booth et al., 2015; Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). The intervention combines three separate strategies aimed at reducing the cognitive load for ADHD students: (1) learning testing strategies to manage the amount of information in test instructions and test questions, (2) studying the strategy through the use of worked examples, and (3) utilizing a memory aid of the strategy while using the extended time testing accommodation.

Cognitive load reduction may be defined as any process that reduces the number of elements of information demanded of working memory (Sweller, 2016). Instructional procedures that reduce the number of elements that require information processing by the test-taker can reduce the cognitive load effects. When a student must attend to multiple pieces of information and integrate them so that they understand the directions they are splitting their attention, and this places a higher demand on WM (Sweller, 2016). Therefore, students learned a testing strategy that was predicted to lessen this cognitive load effect. Each lesson used sample tests and demonstrated to students the strategy which includes: 1) circling direction words, (2) underlining key words, (3) crossing out distractors, and (4) defining key vocabulary in the margins (Appendix F).

The most commonly studied instructional strategy with demonstrated success for reducing cognitive load is worked examples (Booth et al., 2015; Cooper & Sweller, 1987; Kyun et al., 2013; Paas & van Merrienboer, 1994; Pachman et al., 2015; Pawley et al., 2005; Sweller & Cooper, 1985). The strategy requires the student to study a solution to a problem instead of solving the actual problem (Pawley, Ayres, Cooper, & Sweller, 2005). Students learned the testing strategy described above by studying worked examples from sample history tests.
(Appendix F). Additionally, each lesson required the students to demonstrate the strategy after studying the worked examples. Previous studies of worked examples such as Booth et al. (2015) employed a similar instructional strategy for algebra.

According to Baddeley (2012) accessing long-term memory and incorporating it with current information in the visuo-spatial sketchpad and phonological loop requires the use of the central executive of WM. One potential problem with cognitive load reduction testing strategies then, is that they may be counterproductive if students have to access the strategies from long-term memory while attempting to remember the content and instructions of the test. Newell and Simon (1972) demonstrated that external memory aids reduce the cognitive load on WM. To minimize the potential for this additional strain on WM, the final component of the CLRP is for teachers to provide the students in the sample with a memory aid of the testing strategy for their use during unit tests. This did not happen as intended as Chapter 5 will discuss further. The intended intervention of CLRP for students combined learning of a cognitive load reduction strategy from worked examples and employing the strategy with the use of a memory aid during testing.

**Data collection.** I collected quantitative data throughout the three continuous nine-week marking periods and qualitative data in the form of structured participant interviews after the intervention during the third nine-week marking period. The school district maintains scores on a software system called PowerSchool, and the Director of Pupil Services printed student grade reports and redacted the names before providing the reports to me. Additionally, she sent me digital copies through electronic mail. A research assistant conducted and recorded responses from structured interviews of student participants to obtain the qualitative data. The questions
pertained to the CLRP program, how they accessed it, when, and if the teacher told them to complete it (Appendix J).

**Data management.** All research data including paper documents were kept in a locked filing cabinet. Electronic data was stored on the researcher’s computer and a cloud-based storage system which is password protected. Any electronic files will be erased and paper documents shredded, ten years after collection.

All student participants use their own school issued laptop devices to complete online lessons. The school district collects all laptops and erases all student information before graduation. Additionally, the Director of Pupil Services supplied key documents to the researcher with the names and identifying information redacted. The Director of Pupil Services supplied a random number pseudonym for each participant. She kept the student identification list in a separate file, which will be inaccessible to the researcher.

**Data analysis.**

*Systematic visual comparisons of test data.* According to Horner et al. (2005), the most common analysis for single-subject research designs is the use of systematic visual comparisons of within and across conditions. Visual analysis requires the interpretation of (1) level, (2) trend, and (3) variability of performance of the dependent variable during the baseline and intervention phases of the study (see example in Figure 5). Horner et al. (2005) defined level as the mean scores during a phase of the study, trend as the rate of increase or decrease of the best-fit line (slope), and variability as the degree of fluctuation around a mean or slope. The analysis in the following chapter included the immediacy of the effects following an intervention. The final analysis integrated all the information above to determine if there is a relationship between the independent and dependent variables (Horner et al., 2005).
Figure 5

Example of a Multiple Baseline Single-Subject Research Design Visual

Figure 5- The vertical lines indicate the introduction of the intervention at three different points in time. Adapted from Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The Use of Single-Subject Research to Identify Evidence-Based Practice in Special Education. Exceptional Children, 71(2), p. 170.
The dependent variable in the current study was test scores in the participants’ core classes which I charted for the 30-week study. The analysis in the next chapter includes a discussion of the visual chart as it pertains to level, trend, and variability of the data before and after the introduction of the intervention at different times for each participant.

**Descriptive statistics of academic performance.** In addition to the visual comparison analysis of test data, standard measures of central tendency and variability of GPA and class rank provided details of the levels of academic performance before, during, and after the intervention. The analysis included graphs when applicable.

**Descriptive statistics of fidelity of implementation and dose.** I used standard measures of central tendency and variability to provide details of fidelity of implementation and dose of the intervention. The analysis included graphs and tables when applicable.

**Qualitative data of fidelity of implementation, dose, and participant responsiveness.** A research assistant conducted structured interviews with the four student participants to obtain qualitative data and ask questions to determine the fidelity of implementation, dose, and participant responsiveness. Questions focused on their understanding of the program, how they accessed it, when, the amount of teachers’ support, their own perceptions of the CLRP, and its effectiveness.

Student perceptions of the CLPR are an important component of successful implementation. According to Schulte, Easton, and Parker (2009) participants are more likely to be to be responsive to treatment if they found it relevant. Sample questions included, “How useful did you find the CLRP? How often did you use it when taking tests? Did you find yourself using it in other situations in school when you were not taking tests? Do you think other students should learn this strategy?” To assess these perceptions I (1) transcribed the data, (2)
reflected on how the data answered the research questions, (3) looked for disconfirming evidence, (4) compared it to the quantitative data, and (5) interpreted the results according to the methods described by Creswell and Plano Clark (2011). The data were collected concurrent with the quantitative measures, but the qualitative analysis was performed after the quantitative phase. The qualitative data served a secondary role and were used to support the quantitative findings.

**Mixed methods connected data analysis.** The qualitative data collected from student interviews helped explain the quantitative results. I chose to compare participant answers about the impact of CLRP to their test scores and then used a mixed methods joint display table for a visual representation of the analysis.

**Summary Matrices**

The summary matrices below show alignment between the variables, instrumentation, data collection, and data analysis. Each matrix is aligned to the applicable research question and includes all relevant independent, dependent, moderating, and mediating variables.

Table 9

*RQ1: To what extent do high school students with ADHD complete the Cognitive Load Reduction Worked Examples intervention activities and utilize the strategy as intended during testing?*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Instrumentation</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participant Responsiveness</strong> Completion of the CLRP</td>
<td>Participant interviews details, date, and time</td>
<td>Participant interviews</td>
<td>At the end of the study.</td>
</tr>
<tr>
<td><strong>Participant Responsiveness</strong> Understanding of the CLRP</td>
<td>Structured Interviews</td>
<td>Research Assistant</td>
<td>The end of the study</td>
</tr>
<tr>
<td><strong>Participant Responsiveness</strong></td>
<td>Structured Interviews</td>
<td>Research Assistant</td>
<td>The end of the study</td>
</tr>
</tbody>
</table>
Use of the strategy while taking tests

**Participant Responsiveness**
The perceived benefit of the CLRP

**Dose**
Completion of the five CLRP online lessons

<table>
<thead>
<tr>
<th>Variable</th>
<th>Instrumentation</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Performance</td>
<td>Test scores in the core subject classes: science,</td>
<td>Student grade reports from the</td>
<td>Systematic visual comparisons,</td>
</tr>
<tr>
<td></td>
<td>math, social studies, and language arts</td>
<td>PowerSchool software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grades in core subjects</td>
<td>Student grade reports from the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PowerSchool software</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>End of the study</td>
<td>Descriptive statistics</td>
</tr>
</tbody>
</table>

Table 10

**RQ2:** Does learning a cognitive load reduction strategy from worked examples and employing the use of a memory aid of the strategy during testing lead to increased academic performance of high school students with ADHD?

Table 11

**RQ3:** What are ADHD high school student perceptions of the impact of extrinsic cognitive load on test performance?

**RQ4:** How do ADHD students believe the CLRP impacted cognitive load during testing and in the classroom?
<table>
<thead>
<tr>
<th>Variable</th>
<th>Instrumentation</th>
<th>Data Collection Source(s)</th>
<th>Frequency</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student perceptions of extrinsic cognitive load impact on test performance</td>
<td>Structured Interviews</td>
<td>Research Assistant</td>
<td>The end of the study</td>
<td>Interview responses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student perceptions of CLRP impact on academic performance</td>
<td>Structured Interviews</td>
<td>Research Assistant</td>
<td>The end of the study</td>
<td>Interview responses</td>
</tr>
</tbody>
</table>

Table 12

RQ5: *To what extent does the ADHD student perceptions confirm the test score data?*

<table>
<thead>
<tr>
<th>Academic Performance</th>
<th>Test scores in the core subject classes: science, math, social studies, and language arts</th>
<th>Student grade reports from the PowerSchool software</th>
<th>During each nine-week marking period</th>
<th>Mixed methods joint display, mixed methods connected data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student perceptions of extrinsic cognitive load impact on test performance</td>
<td>Structured Interviews</td>
<td>Research Assistant</td>
<td>The end of the study</td>
<td></td>
</tr>
<tr>
<td>Student perceptions of CLRP impact on academic performance</td>
<td>Structured Interviews</td>
<td>Research Assistant</td>
<td>The end of the study</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 5

The cognitive load reduction program (CLRP) intervention implemented with four high school students, each with an Individualized Education Program (IEP) due to a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD), yielded inconsistent results but offered insight into factors that influenced their academic performance. The study began in the fall of 2018 with participants recruitment and baseline measurements. Following the collection of baseline measurements, an intervention occurred at different points for each participant between December 2018 and February 2019. The final stage of data collection, which included grades and participant interviews, concluded in April 2019. The CLRP intervention combined three separate strategies aimed at reducing cognitive load for ADHD students: (1) five online lessons created by the researcher that demonstrated testing-taking strategies to manage the amount of information in test instructions and test questions, (2) practice lessons for the students that required them to study the strategies through the use of worked examples, and (3) utilization of a memory aid of the strategy while using the extended time testing accommodation.

A special education case manager for each participant added the lessons, instructional materials, and memory aid to Schoology. They instructed the students to access the lessons in the order they were presented on the page with one lesson and one practice session each day. The instructional materials were numbered for the students to follow. Each of the five days of lessons included an approximately ten-minute-long instructional video created by the researcher using a document camera which recorded the instructor writing on the document and talking. The instructional videos utilized worked examples to demonstrate the strategy, discussed potential uses, and the rationale for their use. The worked examples in each lesson demonstrated to the students the CLRP which included (1) circling direction words, (2) underlining key words,
(3) crossing out distractors, and (4) defining key vocabulary in the margins (See Appendix F). The videos and corresponding practice sheets used sample tests directions and questions from students’ ninth-grade core subject classes of language arts, social studies, math, and science (Appendix F). The memory aid was a worked example of a difficult social studies essay test question with the instructions and demonstrated strategy which was explained during one of the instructional videos (See Appendix F).

Organizational Framework and Research Questions

The following research questions guided the single-subject, multiple baseline mixed methods study and will serve as the organizational framework for the discussions and findings that follow.

RQ1: To what extent do high school students with ADHD complete the Cognitive Load Reduction Worked Examples intervention activities and utilize the strategy as intended during testing?

RQ2: To what extent does learning a cognitive load reduction strategy from worked examples and employing the use of a memory aid during testing lead to the increased academic performance of high school students with ADHD?

RQ3: What are ADHD high school student perceptions of the impact of extrinsic cognitive load on test performance?

RQ4: How do ADHD students believe the CLRP impacted cognitive load during testing and in the classroom?

RQ5: To what extent do the ADHD student perceptions confirm the test score data?

The following sections of the chapter discuss the fidelity of implementation, the impact of the CLRP on academic performance as measured by quizzes and tests, and participants’ perceptions
of the program. The final discussion of the findings mix the quantitative and qualitative data. Additionally, the chapter addresses the limitations of the research and implications for future research and practice.

**Fidelity of Implementation**

The case manager for each student provided the students access to the lessons on the course management system, Schoology, and one student (Participant 3) never accessed the lessons. Participant 3 did not have a study skills class as part of their normal school day. Therefore, their case manager provided them the instructions to access the lessons on their own time. That the CLRP was additional work outside of the school day may have impacted their unsuccessful completion of the lessons. As a result, that student never received the intervention (Table 13). Each of the other three participants received the intervention at different times according to the multiple baseline methodology (Table 13).

Table 13

**Intervention Schedule**

<table>
<thead>
<tr>
<th>Participant</th>
<th>Week of Intervention</th>
<th>Date of Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>No Intervention</td>
<td>No Intervention</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>Dec. 3rd-Dec. 7th, 2018</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>Dec. 10th-Dec. 14th, 2018</td>
</tr>
<tr>
<td>5</td>
<td>21-22*</td>
<td>Jan. 28th-Feb. 8th, 2019</td>
</tr>
</tbody>
</table>

*The case manager spread out the five lessons over two weeks instead of five straight days.

**Participant responsiveness.** Participant responsiveness has two key components, which are involvement and engagement in the program (Dusenbury et al., 2003). For the current study, measures of involvement included the successful completion of the online learning modules by the student participants and use of the memory aid on tests. Engagement was determined based on use of the strategy on tests when applicable, and a demonstration by the participants that they
knew how to use the strategy. The study also utilized the qualitative data gathered from participant interviews to assess participant responsiveness.

The case managers, special education teachers, and student participants did not implement with fidelity all aspects of the CLRP (Table 14).

Table 14

<table>
<thead>
<tr>
<th>Fidelity of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion of the Online Learning Modules</td>
</tr>
<tr>
<td>P1</td>
</tr>
<tr>
<td>P2</td>
</tr>
<tr>
<td>P3</td>
</tr>
<tr>
<td>P5</td>
</tr>
</tbody>
</table>

Three of the four participants completed the online lessons and worked examples, but none of the participants received the memory aid, which included cues about how to use the strategy during tests. The researcher provided the participants’ case managers and study skills teachers the memory aid digitally in email, on Schoology, and the researcher placed printed copies in their school mailboxes.

Two of the four participants utilized the cognitive load reduction strategy on tests, quizzes, and classroom assignments. Participant 2 reported that they used the strategy on hard test questions and that they found it most useful on essay questions that required multiple parts. Participant 5 indicated that they used similar strategies in the past, but that the lessons were a good reminder. When asked about when the strategy was most useful Participant 5 stated, “I feel like multiple choice questions because if asking for such a specific answers and so there's four answers, and you have to choose one of them. So circling and underlining the key words just
helps get the one right answer.” The feedback from Participant 2 and Participant 5 demonstrated that they used the strategy appropriately on tests, homework, and classwork.

In contrast, Participant 1 did not use the cognitive load reduction strategy as intended. They stated, “It did help me understand it, but personally, I don't know if this is going to be a soon asked question [sic]. I never really used the strategy at all… I personally thought it was too much work.”

Fidelity of implementation requires the use of all three parts of the CLRP for all participants. One participant did not complete any of the components, and the remaining three participants completed five out of the nine. The case managers, special education teachers, and student participants did not implement the intervention with fidelity. The most significant omission was the lack of the use of the memory aid during testing. Newell and Simon (1972) demonstrated that external memory aids reduce the cognitive load on WM. Therefore, without the memory aid, the students’ WM during tests could have been affected by the additional strain required to access the CLRP from long-term memory.

**Intervention dose.** According to Dusenbury et al. (2003), measuring dosage may be necessary when non-research personnel are delivering the intervention. Special education teachers implemented the CLRP during the participants’ specialized instruction time or provided it to the participants to complete at home. The method of delivery was the pre-prepared computer modules on the Schoology course management system. To insure fidelity of dose, students were asked to complete all five training sessions, worked examples, and use the memory aid on tests and quizzes. As discussed above, three of the four participants completed all the training sessions and worked examples practice. However, none of the students used the memory aid on tests and quizzes.
Impact of the CLRP on Academic Performance

The current study utilized a single-subject multiple-baseline mixed method embedded research design (QUAN > qual) to answer the questions above. A key component in a single subject design is the continual and frequent measurement of the dependent variable before and after the intervention, which in this study was introduced at different times for each participant (Horner et al., 2005). The dependent variable in the study was the participants’ academic performance, which was defined as levels of accomplishment attained in regular education classes, as demonstrated by scores on homework, classwork, quizzes, projects, and course exams. Core classes (social studies, language arts, math, and science) provided the most opportunities for the use of the strategy and test scores served as the short-term outcome measure as students took frequent tests and quizzes in these classes. Class grades served as the medium-term outcome measure as they are largely dependent on improved test scores in the core classes. Class grades combine the results of homework, classwork, projects, quizzes, and tests. Therefore, they are an appropriate measure of academic performance.

Results are reported as weekly mean scores across all four classes. This method was necessary because students did not take weekly quizzes or tests in each of their core classes. For each participant, the range of tests and quizzes per week varied from some weeks with no tests and quizzes to other weeks when six scores were reported. Furthermore, teachers have total discretion to assign the point values of each test or quiz, the point values assigned to each question on a test or quiz, the number of quizzes and tests during a week, and percent they contribute to a students’ overall grade. The scores for each participant are reported from four different classes and a total of 16 different teachers. The percentage score was the only consistent measure across all teachers’ gradebooks. Therefore, the reported outcomes included
the total percentage on each test or quiz instead of the raw score. For example, a participant may have received a nine out of ten points on a quiz in math during week one and a 43 out of 50 points on a test in social studies the same week. The scores reported are an average of the two percentages, e.g. \((90\% + 86\%)/2 = 88\%\), instead of a calculation of the participant’s total score then turned into a percentage, e.g. \((52/60) \times 100 = 86\%\).

The school district maintains scores on a software system called PowerSchool, and the Director of Pupil Services redacted, printed and, emailed student grade reports to the researcher. The grade reports included the due dates, raw scores, and percentage grade on each assignment in all four core classes for each participant for three nine-week marking periods and three extra weeks added due to snow days which extended the marking periods.

The single-subject design utilized a systematic visual comparison of within and across conditions to examine the effect of the CLRP on academic performance (Figure 6). According to Horner et al. (2005), the visual analysis is the most common method, and requires the interpretation of (1) level, (2) trend, and (3) variability of performance of the dependent variable during the baseline and intervention phases of the study.

Figure 6

*Systematic Visual Comparison of the Effects of a CLRP on Test and Quiz Performance*
Figure 6 - The line graphs display the level, variability, and trend of academic performance of all participants throughout each phase of the study. The dark vertical line in each bar graph represents the point in time when the participant received the intervention.

Further analysis of the level, variability, and trend follows in the next sections.

**Level and variability.** Horner et al. (2005) defined level as the mean scores during a phase of the study and variability as the degree of fluctuation around a mean or slope. This study used the test and quiz scores for participants’ four core classes for short term performance
measures of academic achievement and percentage grades for each marking period as medium term outcome measures.

Participant 1 demonstrated the highest academic performance throughout the study and showed a slight decline from the pre-intervention mean score of 93% to 89% during the post-intervention phase of the study. In addition to earning the highest test and quiz scores, this participant demonstrated the smallest variability of scores of 8% pre-intervention and 10% post-intervention.

The test and quiz scores for Participant 2 remained the same for the pre and post intervention phases (M = 83%, STD of Pre = 11%, STD of post = 16%), and their scores revealed greater variability than Participant 1. Participant 5 began the study with the lowest academic performance of the four participants (M = 78%, STD = 17%) and had the greatest variability of scores (Table 15). The variability of scores in the present study was somewhat related to overall academic achievement such that participants with the lowest mean test and quiz scores displayed the greatest variability. This finding is likely due to the presence of more extreme scores at the lower ends of the test and quiz range. For example, scores for Participant 5 ranged from 43% to 100%, whereas those for Participant 1 ranged from 64% to 100%.

Table 15

*Test and Quiz Score Averages for Each Phase of the Study*

<table>
<thead>
<tr>
<th></th>
<th>Pre-Intervention Test/Quiz Scores</th>
<th>SD</th>
<th>The Week of the Intervention Test/Quiz Score</th>
<th>Post-Intervention Test/Quiz Scores</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>93%</td>
<td>8%</td>
<td>91%</td>
<td>89%</td>
<td>10%</td>
</tr>
<tr>
<td>P2</td>
<td>83%</td>
<td>11%</td>
<td>75%</td>
<td>83%</td>
<td>16%</td>
</tr>
<tr>
<td>P5</td>
<td>78%</td>
<td>17%</td>
<td>79%</td>
<td>78%</td>
<td>14%</td>
</tr>
<tr>
<td>M</td>
<td>85%</td>
<td></td>
<td>82%</td>
<td>83%</td>
<td></td>
</tr>
</tbody>
</table>
In overview, the mean of all participants’ test and quiz scores remained the same in the post-intervention phase as compared to those in the pre-intervention phase. They perhaps reflected slight decrease in the variability (M = 78%, STD = 14%) in the post-intervention phase. Figure 7 shows that, on average, participants’ scores during each of the phases did not demonstrate an improvement in test and quiz results across all their classes.

Figure 7

*Pre and Post Intervention Test and Quiz Scores*

As measured by test and quiz score averages, Participant 1 demonstrated a small decline in performance throughout each phase of the study. This finding could be a result of the ceiling effect which is discussed in more detail later in this chapter. Participant 2 and Participant 5 mean scores remained the same for pre and post intervention (Figure 7). Also, the scores during the weeks of the intervention did not demonstrate improvement, and two of the three participants received worse scores on tests and quizzes during the week of their intervention. Participant 1 and Participant 2, however, each took just one quiz during the week of the intervention, while Participant 5 received two scores during the two-week intervention period.
**Trend.** Horner et al. (2005) defined trend as the rate of increase or decrease of the best-fit line (slope). Two of the three participants’ trend lines changed from a negative slope during the baseline period to a positive slope in the intervention phase (Figure 8).

Figure 8

*The change in the trend of Test and Quiz Scores for Participants 2 and 5*
Figure 8. The vertical lines represent the implementation of the intervention. The dotted lines demonstrate the change in trend following the intervention for both participants.

In contrast to the improved change in the trend of Participants 2 and 5, Participant 1 did not demonstrate a positive change in test and quiz scores; in fact, that scores of Participant 1 showed a negative trend in their scores throughout the study. The trend of Participant 1 was similar to the trend of Participant 3, who did not receive the intervention. As discussed earlier, Participant 1 did not implement the intervention. Interestingly, a recent paper by French, Sycamore, McGlashan, Blanchard, and Holmes (2018) states that high achieving students often notice a decline in scores due to the ceiling effect.

The immediacy of the effects. According to Horner et al. (2005), an additional typical technique for data analysis is to determine the immediacy of the effect. A method sometimes used in single-subject design, such as the study by Ashbrook, Gilham, and Barbara (2018), is to test immediacy of an effect by using the mean of the last three data points just before the intervention and the first three data points during and after the intervention. If the intervention phase is higher than the last data before the intervention, it signifies an immediate improvement. One of the three participants demonstrated an immediate effect (P5) with a slight improvement from 70% to 75%. P1 demonstrated a stable score of 94% at the end of the baseline and 93% during the intervention phase. P2 showed a decline in scores (Table 16). However, the most immediate test and quiz results did not occur for P2 until almost a month after the student received the CLRP. Despite Participant 1 and Participant 5 showing an increase immediately following the intervention, the mean score of all three participants does not demonstrate an immediate effect due to the larger drop in scores for Participant 2, indicating that the effects, if any, are out of phase across participants. However, as discussed, these results may not demonstrate immediacy due to the time lag between the intervention and first data points.
Table 16

Immediacy of Effects

<table>
<thead>
<tr>
<th></th>
<th>Last Three Data Points-Baseline</th>
<th>First Three Data Points-Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>93%</td>
<td>94%</td>
</tr>
<tr>
<td>P2</td>
<td>68%</td>
<td>60%</td>
</tr>
<tr>
<td>P5</td>
<td>70%</td>
<td>75%</td>
</tr>
<tr>
<td>Mean</td>
<td>77%</td>
<td>76%</td>
</tr>
</tbody>
</table>

Participants’ Perceptions of the CLRP

The research assistant interviewed participants following the final phase of quantitative data collection to determine their perception of the CLRP and how they believe it impacted their academic performance. Their perceptions of the CLRP varied, from Participant 1 who did not find it useful, to Participant 5 and Participant 2 who believed it was helpful and should be taught to some students.

Participant 1 did not believe the strategy was useful for them. They stated, “I personally thought it was a little bit too much work. It was a little bit busy work, and I found that at the end of the thing, that I spent more time trying to find the definitions and the underlining than the time I could have worked on processing the project in a more simpler [sic] way.” However, Participant 1 did believe that some students could benefit from the CLRP. “I think it's a good strategy for kids who have trouble processing directions… it would probably work for any multiple choice that are really long or projects, but I just tend to underline the most important information.” Participant 1 exhibited higher achievement with an “A” average in their classes from the beginning of the study. Therefore, such a student may have been less likely to embrace a strategy targeted at academic improvement.
Participant 5 exhibited the lowest academic performance at the start of the study and positively perceived some components of the CLRP. This participant demonstrated that they understood the purpose of the CLRP when they stated, “Makes it a lot more simple [sic]. Instead of trying to remember what the whole question is asking if you break it down into just three or four words and the question to make it what the question is really asking but shorter, it just makes it a lot more simple [sic].” Additionally, they found the strategy helpful on homework too. Finally, they stated that overall, they believed that they were a much better student as a result of learning the strategy and that other students who struggle should learn the strategy.

Participant 2 also demonstrated an understanding of the strategy and the benefits of using it. They stated, “It's pretty useful. Like I said, it breaks it all down.” Additionally, they discussed multiple different situations when they used the CLRP beyond testing. “Sometimes I'll do it while reading a book. Because it's kind of like same thing, it's just in a book and how students could benefit from it… if I'm not really understanding what the book is meaning, I could use that and go back, and it break down and understand [sic].” Finally, Participant 2 believed that other students should learn the strategy and that they personally benefitted from it.

In total, two of three participants believed they personally benefitted academically from learning the CLRP and, all three participants believed that students who struggle academically should learn the strategy.

**Quantitative and Qualitative Data Merge**

The benefits of a mixed methods embedded design (Quan> qual) is that the second strand of qualitative data is different but tied to the first. It also helps explain the picture revealed from numerical data through the inclusion of narrative (Creswell & Plano Clark, 2011; O’Leary,
In the present study, the qualitative data gathered from participant interviews confirmed the quantitative results (Table 17).

Table 17

**Joint Display of Quantitative and Qualitative Data**

<table>
<thead>
<tr>
<th>Level</th>
<th>Trend</th>
<th>Variability</th>
<th>Completion of Online Lessons</th>
<th>Use of Memory Aid</th>
<th>Use of the Strategy on Tests and Quizzes</th>
<th>Perception of the Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>Decline</td>
<td>Decrease 8%,10%</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Negative</td>
</tr>
<tr>
<td>Participant 2</td>
<td>Same</td>
<td>Increase 11%,16%</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Positive</td>
</tr>
<tr>
<td>Participant 3</td>
<td>Same</td>
<td>Decrease 17%,14%</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Positive</td>
</tr>
</tbody>
</table>

Participant 1 had the highest academic performance and the least amount of variability of scores throughout the study. However, they declined in test and quiz scores from the baseline phase through the intervention phase. This result was unexpected as the hypothesis stated that student participants should benefit academically from partaking in the online lesson and implementing the CLRP. While Participant 1 completed the CLRP online modules, they indicated during their interview that they did not use the strategy on tests, quizzes, or coursework because they believed it was too much additional work. Their slight decline in performance may not indicate anything because it could be due to the ceiling effect. According to French et al. (2018), ceiling effects occur when the sample is in the upper range of a measurement scale. The result is that the dependent variable is no longer measurable, and variance decreases. When the ceiling effects are present, the measure does not adequately assess the participants’ ability (French et al., 2018).

Participant 3, who did not complete the CLRP, had a decline in scores similar to Participant 1 during the same period of the study with negatively trending test and quiz scores.
In comparison, the two participants that completed the CLRP program, used it on tests, quizzes, coursework, and had faith in the program as indicated in the interviews, did not see a drop in performance throughout the phases of the study. Furthermore, the trend in the test and quiz scores rose following the intervention at week 15 for Participant 2 and week 21 for Participant 5. Thus, the qualitative data confirmed the relative success of the CLRP. Participants that believed in and utilized the CLRP manifested benefits in their academic success, and the participants that did not use the CLRP saw a decline in performance throughout the 30 weeks of the study.

**Discussion and Limitations**

**Experimental effect and non-responders.** Single-subject research must demonstrate the impact of an intervention at three or more points in time within a single subject or three or more points in time with multiple subjects (Horner et al., 2005). By these criteria, the following study did not demonstrate an experimental effect as only two of the participants displayed improvement following the intervention. However, Horner et al. (2005) state that the benefit of single-subject research is that it allows for targeted analysis of individuals within heterogeneous populations.

Randomized control trials also include non-responders, which are defined as individuals who are unaffected or made worse by the intervention (Horner et al., 2015). Single-subject designs allow for an analysis of potential factors associated with non-responders as well as those participants who received a benefit from the intervention. Such is the case with the present study. Participant 1 was a non-responder as that student did not see a benefit from the intervention as their scores declined throughout the study. While it cannot be known if they would have benefitted had they employed the CLRP, Participant 1 did discuss reasons for their rejection of it, which could be useful to know should someone employ this strategy with other
students. Alternatively, as discussed above, their decline in scores could be the result of the ceiling effect. As the aim of the study was to improve the performance of underachieving students with ADHD, future studies with the same goal could exclude participants such as Participant 1 if their academic performance is above a certain threshold.

While the study did not demonstrate dramatic short-term improvements in test and quiz scores or medium-term outcomes in grades, test and quiz scores of two participants that utilized the strategy displayed an improving trend which could result in progressively greater improvement over the long-term. Each of these two participants, also mentioned that they utilized the strategy at various times. For example, Participant 2 stated that they used the strategy when faced with really hard test questions or when reading a book. Although this is difficult to evaluate, the number of “really hard” test question point values is probably marginal compared to the total number of points that comprise their grades, and this may have diluted the effect. The benefit, therefore, may have been greater than the measure used to quantify it. Future studies that examine specific instances of benefit that students receive from this or a similar program could identify or focus on the most affective uses of the strategy. Participant 2 and Participant 5 both believed they received a benefit from the CLRP, thus supporting the conclusions from the quantitative trends.

A Differential Boost

One of the central motivations for implementation and design of this intervention was that very few accommodations exist in the research literature for students with ADHD that clearly improve academic performance. Harrison et al. (2013) proposed that “accommodations are changes to practices in schools that hold a student to the same standard as students without a disability but provide a differential boost to mediate the impact of the disability on access to the
general education curriculum” (p. 556). The current study did not include non-ADHD students as controls, and, therefore, was not able to determine if there was a differential boost in academic achievement as a result of the CLRP. However, the data indicated that the two students with ADHD who did not implement the cognitive load reduction strategy saw a decline in performance, and the two students who implemented it generally maintained their academic performance. It is possible that the two participants who did not implement the strategy experienced regression effects to their normal levels of performance which Shadish et al. (2015) identified as a threat to internal validity in a single-subject design. Regression effects are a problem that Shadish et al. (2015) identified for participants that are the extreme ends of a population. The population of ADHD students with an IEP meets the criteria of the extreme end as they typically underperform academically compared to their non-ADHD peers. Another possible explanation is that the instrumentation varied over time. If tests and quizzes became more difficult as the school year progressed, the performance of Participant 2 and Participant 5 may have improved more than the data indicated. Further research could utilize a non-ADHD control or randomized control trial of students with ADHD to identify if the differential boost is a result of academic regression during the normal course of a school year.

**Threats to External Validity**

One of the most significant threats to external validity in the present study was the small sample size (n = 4). The potentially unrepresentative sample size may not generalize to the larger population of high school students with ADHD. While this limitation is evident, Shadish et al. (2015) explained that the fear is often overstated when discussing single-subject designs such as the current study. To address the limitation, it is important in single-subject designs to describe the context and participants which the current study satisfied. Random sampling, too,
rarely contains all possible cases of treatment across settings, dosage, providers, and variations in the measurements of the observed outcomes (Shadish et al., 2015). The current study described the intervention, participants, and setting and found instances of success and possible reasons for non-responders.

Attrition is a threat to internal and external validity when one only publishes the results of the successful cases or limits the range from possible examples. The current study minimized the threat by including full details for the participant who did not complete the study and the participant that did not implement the strategy. In addition to preventing attrition bias, they each provided a useful controlled comparison.

**Challenges of Special Education Research**

One of the lessons learned from the current study is the challenges of conducting special education research. Student participants’ privacy during recruitment and the implementation of the intervention was complicated by my dual role as a teacher and researcher.

**The importance of the special education teachers.** The population of students at Nest View High School with ADHD and an IEP is small (n = 40) and the administrative and legal restrictions limited the recruitment methods by keeping the identity of a student with learning disabilities anonymous from those who do not need to know. After the initial recruitment phase, the sample was beneath the target number of three to eight participants needed for a single-subject design. As a result, I was compelled to recruit from a larger population of two additional high schools. Expanding the population, however, meant that the distribution of materials and communications occurred over email. It was evident that many instructions to the case managers and special education teachers were not carried out as demonstrated by the fidelity of implementation data. As one of the most important stakeholders, I needed to consult with the
special education teachers, involve them in the planning process, and collaborate with them throughout the implementation process. The collaboration and planning was not as affective over email compared to my interaction with colleagues within my school building.

A specific issue with some of the special education teachers was that they did not believe in the program or did not fully read and understand the how and why of the CLRP. That they were instrumental in the delivery of the services and did not implement all aspects of the CLRP demonstrated the need to expand the teacher professional development (PD) of the special education teachers and improve maintenance of the PD beyond email exchanges.

**The legal rights of the parents and students.** Policy implementation must not violate established legal rights and this is especially so with special education. The *Individuals with Disabilities Education Act* (IDEA, 1975, Amended, 2004) requires school districts to provide educational supports and interventions to students with disabilities such as ADHD. One of the established rights in the IDEA (2004) is that school district staff must not disclose a students’ learning disability with anyone not associated with the child’s education. It protects the student, thus making the job of recruitment and retention of participants a significant challenge. According to Cook, Godiwall, Brooks, Powers, and John (2010) recruitment and retention of participants is an obstacle in most studies and, the addition of the privacy laws enacted as part of IDEA (2004) made it even more challenging. As a teacher, the school district informs me of the students’ disabilities, IEP, and accommodations. As a researcher I do not have the right to know unless the parents’ provide consent. The practical implications of the law for a researcher includes not knowing the identity of the population or having direct contact with them. As a result, the research relied on email recruitment delivered by key school district administration with privileged access to student names, academic records, and parental email addresses.
Power and coercion. As is true for any study, an additional consideration involved maintaining the anonymity of student participants throughout the study to avoid issues of power and coercion. Students in my own classes, for example, might feel compelled to participate because out of fear that it could impact their grades. As a result, I could not directly administer the intervention and ensure treatment fidelity. That students did not receive the memory aid of the testing strategy is evidence of the difficulty of relying on other staff to properly deliver the treatment program.

Mediating variables. Horner et al. (2005) state that single-subject design is a necessity in special education research due to the low incidence of many of the variables, and heterogeneity of the population. Mediating variables that may have had impact on the success of the intervention included rigor of current coursework, home support, learning disability support within the school, motivation, emotional factors, the extent of WM deficits, and level of performance prior to the intervention. For example, some of the students in the study received specialized instruction during the school day tailored toward their disability and some of the student participants did not. Participant 1 demonstrated better academic performance at the start of the study than the other participants. Different levels of motivation appeared to be a factor for some students as Participant 1 expressed in their interview that the CLRP was too much work, whereas Participant 3 found it extremely helpful.

Conclusions

The Cognitive Load Reduction Program aimed at improving the academic performance and achievement of high school students with Attention-Deficit/Hyperactivity Disorder demonstrated moderate levels of success with some students. The results suggested that students who completed the online lessons and utilized it in their academic coursework experienced a
positive support and potential benefit. The participants that did not complete the lesson or implement the strategy had a regression in overall grades, test, and quiz scores.

Students may demonstrate an even greater benefit from the CLRP than recorded and the observations from this study may inform future research. Changes might involve excluding high achieving students such as Participant 1 and, including control conditions to determine if regression in scores during the year is common and potentially avoided by the CLRP. Another potential change in future studies is to administer a placebo intervention to a randomized group to determine if it is the belief in the CLRP or the intervention that resulted in improved performance. Lastly, future studies could test for specific instances when the CLRP is most effective such as difficult test questions. The measure of academic performance in the current study was too far removed from the intervention and inconsistent for each participant and class. Refining a measurement tool administered to all participants at various points could be a potential alternative in future research and possibly demonstrate specific instances that the CLRP helps ADHD students’ academic performance that may not have been measured in the current study.

Research with a special education population is difficult to accomplish, as this study demonstrated. Despite a large school district and a population of over 100 high school students with ADHD, only three participants completed the study, and there were many obstacles to administering the intervention and collecting the data as the fidelity of implementation demonstrated. More research, as described above, and greater access to students who need it by researchers are required to help students with learning disabilities such as ADHD reach their full academic potential. Despite the difficulties of conducting special education research, the findings from the current study suggest that the CLRP for high school students with ADHD may
be a possible intervention to provide a needed differential boost for students who often struggle academically.
References


doi:10.1007/s10802-016-0171-7


doi:10.1371/journal.pone.0198426


doi:10.1177/0192636508314106


*Exceptional Children, 71*(2), 165–179.


doi:10.1002/pits.20342


Martinussen, R., Tannock, R., & Chaban, P. (2011). Teachers’ reported use of Instructional and behavior management practices for students with behavior problems: Relationship to role and level of training in ADHD. *Child & Youth Care Forum, 40*(3), 193–210. doi:10.1007/s10566-010-9130-6


doi:10.1037/a0022045

doi:10.1080/0144341042000294903

Pelham, W., Foster, M., & Robb, J. (2007). The Economic impact of Attention-
Deficit/Hyperactivity Disorder in children and adolescents. Ambulatory Pediatrics, 7(1),
121–131. doi:10.1016/j.ambp.2006.08.002

Academic testing accommodations for ADHD: Do they help? Learning Disabilities: A
Multidisciplinary Journal, 21(2), 67–78. doi:10.18666/LDMJ-2016-V21-I2-741

Purdie, Hattie, & Carroll. (2002). A review of the research on interventions for Attention Deficit
99. doi:10.3102/00346543072001061

Quach, D., Mano, K., & Alexander, K. (2016). A randomized controlled trial examining the
effect of mindfulness meditation on working memory capacity in adolescents. Journal of
Adolescent Health, 58(5), 489–496. doi:10.1016/j.jadohealth.2015.09.024


graduation from four-year colleges. Chicago: University of Chicago Consortium on Chicago School Research.


Schwaighofer, M., Bühner, M., & Fischer, F. (2016). Executive functions as moderators of the worked example effect: When shifting is more important than working memory capacity. *Journal of Educational Psychology, 108*(7), 982. doi:10.1037/edu0000115


Appendix A

Interview with a School Guidance Counselor

Introduce my topic and goals for the interview. 1. ADHD academic underachievement in high schools 2. I want to determine if that is true at WCASD 3. I intend to examine IEPs, 504s and the accommodations, modifications, and interventions within them. My purpose for the interview is to better understand the process at WCASD and your role in it. Your answers will be anonymous.

1. Do you have a lot students on your caseload with IEPs or 504s for ADHD?

Not a lot. ½ of 504s. ADHD. Not always diagnosed. Executive Function Disorder

2. How do they get selected? Do the IEPs and 504s typically follow them from middle school, transfer from other high schools, parents ask for evaluations, teachers recommend? What is the most common?

A lot come from middle school.

Changes when they transition to high school.

3. If we receive them from middle school, what is the process to transfer the IEP or 504 to high school?

Meeting- counselor, student, family

- What works, what doesn’t
- Concerns for high school
- Occasionally meet again 1st nine weeks.

3b. If someone says they want them tested what is the process?

Teacher feedback. Talk to family doctor. Teacher observation forms.

Child study > permission to evaluate > teams are a state requirement > trial interventions > flag form check in with student > extended time > test grades > testing is a last resort.
Testing takes a lot of time and money. Lots of supporting reasons.

1) Data 2) discipline 3) attendance 4) grades 5) teacher feedback

3c. If they come from another school, what is the process?

3d. If they come from a teacher?

4. Do students come with a diagnosis of ADHD from an outside evaluation or is that determination made at WCASD?

Typically a family doctor evaluates- rating scales.

Dr. > sometimes prescribes > has to impact education to get a 504 > they don’t always use them > look at grades.

5. What types of tests are used?

6. When is an IEP utilized versus a 504?

Better for psychologists to answer.

7. What input do you have for the accommodations and modifications included in the IEP or 504?

Child study team- psychology

1) Grade
2) Admin
3) RTII
4) Psychologist

8. Do you have knowledge of the cognitive deficits that may be associated with the students’ ADHD? If so, how?
Guidance wouldn’t know unless psychologist did testing.

9. Are cognitive deficits considered when selecting accommodations and modifications?
Processing speed.
Preferential seating, reduced distractions, extended time (hard to make that call), guided notes.
“ Doesn’t make sense” > 1. Reduces anxiety 2. Too much time.

10. (Optional Question based on previous answers) What accommodations do you use for deficits in working memory?

11. (Optional Question) What accommodations do you use for deficits in working memory inhibition?
12. According to a study by Murray et al. (2014) extended time is the most frequently implemented accommodation for ADHD. Do you include this accommodation and if so why?

See number 9

13. Thank you so much. Is there anything else you would like me to know?

Thank you and I will keep you abreast of my research as I move forward. Thanks again for your time and expertise.
Appendix B

Interview with a School Special Education Teacher

Introduce my topic and goals for the interview. 1. ADHD academic underachievement in high schools 2. I want to determine if that is true at WCASD 3. I intend to examine IEPs, 504s and the accommodations, modifications, and interventions within them. My purpose for the interview is to better understand the process at WCASD and your role in it. Your answers will be anonymous.

1. Do you have a lot students on your caseload with IEPs or 504s for ADHD?

Other health impairment due to ADHD 15/17. Comorbidity to go with ADHD

2. How do they get selected? Do the IEPs and 504s typically follow them from middle school, transfer from other high schools, parents ask for evaluations, teachers recommend? What is the most common?

Ask school psychologist

A lot from middle school. diagnose

3. If we receive them from middle school, what is the process to transfer the IEP or 504 to high school?

Transition meeting, revision for high school.

Annual IEP, revisions can occur early 9th-grade if it doesn’t work.

3b. If someone says they want them tested what is the process?

3c. If they come from another school, what is the process?

3d. If they come from a teacher?

4. Do students come with a diagnosis of ADHD from an outside evaluation or is that determination made at WCASD?
5. What types of tests are used?

6. When is an IEP utilized versus a 504?
Better for psychologists to answer.

7. What input do you have for the accommodations and modifications included in the IEP or 504?
Follow a template. Reevaluate every three years. Initial evaluation. Special ed. can take it out- no meeting revisions. Parent pushback equals full meeting. Follow up question- What is the source of the accommodations? Special ed gets a list. SP. Reg. ed. LEA. Admin. guidance.

8. Do you have knowledge of the cognitive deficits that may be associated with the students’ ADHD? If so, how?
Eval report. Reevaluation- components 1) testing 2) issues in class 3) progress reports 4) further testing
Reluctance to test. Easier for school psychologist than special ed to request testing.

9. Are cognitive deficits considered when selecting accommodations and modifications?
Word banks, processing
Wait time
Weschler – working memory

10. (Optional Question based on previous answers) What accommodations do you use for deficits in working memory?
Focus more on LD
1) Study guides 2) word banks 3) cheat sheet - Note she said these are not for WM.
11. (Optional Question) What accommodations do you use for deficits in working memory inhibition?

“I listen to the teacher, then try to include it.”

12. According to a study by Murray et al. (2014) extended time is the most frequently implemented accommodation for ADHD. Do you include this accommodation and if so why?

“Gives them time to process.”

“Gives them a chance to write out thoughts for later retrieval.”

Distracted if not separated for testing.

13. Thank you so much. Is there anything else you would like me to know?

Thank you and I will keep you abreast of my research as I move forward. Thanks again for your time and expertise.
Appendix C

Interview Notes with a School Psychologist

Introduce my topic and goals for the interview. 1. ADHD academic underachievement in high schools 2. I want to determine if that is true at WCASD 3. I intend to examine IEPs, 504s and the accommodations, modifications, and interventions within them. My purpose for the interview is to better understand the process at WCASD and your role in it. Your answers will by anonymous.

1. Do you have a lot students on your caseload with IEPs or 504s for ADHD?
A lot of referrals. Don’t always qualify.

2. How do they get selected? Do the IEPs and 504s typically follow them from middle school, transfer from other high schools, parents ask for evaluations, teachers recommend? What is the most common?
Parents
Sometimes teachers

3. If we receive them from middle school, what is the process to transfer the IEP or 504 to high school?

3b. If someone says they want them tested what is the process?

3c. If they come from another school, what is the process?
Only s.p. if they need to reevaluate.

3d. If they come from a teacher?

4. Do students come with a diagnosis of ADHD from an outside evaluation or is that determination made at WCASD?

5. What types of tests are used?
Cognitive assessment – IEP, not a 504
ADHD- behavioral rating
Neuropsych. Evaluation- not comprehensive. Subtests. DCAFS, NEPSI

6. When is an IEP utilized versus a 504?

Told by lawyers- ADHD > IEP
Child study team- PSSA, Keystone, failing grades.
Only if they don’t qualify for 504. Usually isn’t effective.

7. What input do you have for the accommodations and modifications included in the IEP or 504?

8. Do you have knowledge of the cognitive deficits that may be associated with the students’ ADHD? If so, how?

Yes, tests for 1) WM 2) inhibition 3) executive function

9. Are cognitive deficits considered when selecting accommodations and modifications?

Study skills. Planning out long-term, organization, testing room, resource room to learn.

10. (Optional Question based on previous answers) What accommodations do you use for deficits in working memory?

11. (Optional Question) What accommodations do you use for deficits in working memory inhibition?

12. According to a study by Murray et al. (2014) extended time is the most frequently implemented accommodation for ADHD. Do you include this accommodation and if so why?

Slow processing speed
Testing room is important
Rarely given for assignments.
13. Thank you so much. Is there anything else you would like me to know?
Dear Parents and Students,  

I am currently a doctoral student at Johns Hopkins University, and we are inviting you to participate in a research study. The purpose of the study is to examine the accommodations implemented on Individualized Education Programs (IEP) and 504 plans for students with Attention-Deficit/Hyperactivity Disorder (ADHD). Additionally, the study will analyze possible links between the frequency and severity of working memory deficits and if they impact accommodations, academic performance, and achievement.

We are seeking your permission to review educational records pertaining to your child. All data collected will be strictly confidential (see consent for more details), and your participation in this study is completely voluntary. If at any time during the study you or your child choose not to participate, you may opt out with no penalty to you or your child.

If interested in participating, please return the consent form by April 12, 2017.

Thank you in advance for your consideration and please feel free to contact me if you have any questions about this research.

Respectfully,

Brent A. Jones

East High School Social Studies Teacher

bjones90@jhu.edu

(484)-266-3800
Dr. Christine Eith, Principal Investigator
Assistant Professor, School of Education | Johns Hopkins University
Appendix E

Student Assent and Parental Informed Consent for the Needs Assessment Study

Johns Hopkins University

Homewood Institutional Review Board (HIRB)

Student Assent and Parental Informed Consent

Title: Attention-Deficit/Hyperactivity Disorder (ADHD), Working Memory, and Academic Achievement

Principle Investigator: Dr. Christine Eith

Date: April 5, 2017

PURPOSE OF RESEARCH STUDY:
The purpose of the study is to examine the accommodations implemented on Individualized Education Programs (IEP) and 504 plans for students with Attention-Deficit/Hyperactivity Disorder (ADHD). Additionally, the study will analyze possible links between the frequency and severity of working memory deficits and if they impact accommodations, academic performance, and achievement.

PROCEDURES:
There will be several components for this study:

1. The researcher will collect key documents related to your child: Evaluation Reports, Revaluation Reports, Individualized Education Programs, 504 Plans, Standardized Test Scores, and Report Cards.
2. The researcher will code the documents using the software Statistical Package for the Social Sciences (SPSS).
3. The researcher will analyze the data and write a report
TIME REQUIRED:
The study will require no time for you or your child. All the information will be obtained by the researcher from the key documents.

RISKS/DISCOMFORTS:
There are no anticipated risks to participants.

BENEFITS:
Information gained from this study will be used to justify further research and possible interventions to improve the academic outcomes for students with ADHD.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:
Participation in this study is entirely voluntary. You choose whether to participate. If you choose not to participate, there are no penalties, and neither you nor your child will lose any benefits to which you would otherwise be entitled.

You can stop participation in the study at any time, without any penalty or loss of benefits. If you want to withdraw from the study, or to stop participating, please contact Brent A. Jones via phone or email: (484) 266-3800, bjones90@jhu.edu.

CONFIDENTIALITY:
Any study records that identify you or our child will be kept confidential to the extent possible by law. The records from your participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the Office for Human Research Protections. (All of these people are required to keep your identity
confidential.) Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all the student’s achievement scores, performance measures, IEP, 504 plans, Evaluation Reports, Revaluation Reports, and Report Cards.

All research data including paper documents will be kept in a locked filing cabinet.

Electronic data will be stored on the researcher’s computer, which is password protected. Any electronic files will be erased and paper documents shredded, ten years after collection.

Only group data will be included in publication; no individual achievement data will ever be published.

**COMPENSATION:**

You will not receive any payment or other compensation for participating in this study.

**IF YOU HAVE QUESTIONS OR CONCERNS:**

You can ask questions about this research study at any time during the study by contacting via phone or email: (484) 266-3800, bjones90@jhu.edu.

If you have questions about your rights as a research participant or feel that you have not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

**SIGNATURES**

**WHAT YOUR SIGNATURE MEANS:**

Your signature below means that you understand the information in this consent form. Your signature also means that you agree to participate in the study.
By signing this consent form, you have not waived any legal rights your child otherwise would have as a participant in a research study.

___________________________________________________________________________
Signature

___________________________________________________________________________
Signature of Person Obtaining Consent
(Investigator or HIRB-Approved Designee)

Page 3 of 174

(ADHD, Working Memory, and Achievement) Parent & Assent Form (04/05/17)
Appendix F

Worked Examples Practice Lesson

Teacher's Name Only.
Directions: Use the working memory strategy pictured below for each set of directions.

1. Review the Supreme Court decision in Bethel School District No. 403 v. Fraser.
   - Circle the direction words
   - Underline the key vocabulary
   - Count the Steps
   - Define the terms in the margins

2. Summarize the majority and dissenting opinions and analyze the media's response to the decision. Conclude your response by discussing your personal view, given the evidence brought forth by both sides.

   # 1

   **Task** Using information from the documents and your knowledge of history, write an essay in which you:
   - Examine the accomplishments of the early river civilizations.
   - Discuss how those accomplishments affected life in each civilization.

   # 2

   **Directions:** Answer the following question. It is not enough to answer a question by merely listing facts. You should present an argument based on your critical analysis of the question posed, using appropriate terminology.
Appendix G

Memory Aid of CLRP

1. Review the Supreme Court decision in Bethel School District No. 403 v. Fraser.

2. Summarize the majority and dissenting opinions and analyze the media's response to the decision. Conclude your response by discussing your personal view, given the evidence brought forth by both sides.

- Circle the direction words
- Underline the key vocabulary
- Count the Steps 4  
- Define the terms in the margins
Appendix H

Participant Recruitment Cover Letter

Dear Parents,

September 20, 2018

I am currently a doctoral student at the Johns Hopkins University, and we are inviting you to participate in a research study. The purpose of the study is to examine strategies to assist students with Attention-Deficit/Hyperactivity Disorder (ADHD).

We are seeking your permission to review educational records pertaining to your child including their Individualized Education Program (IEP), Evaluation Report, and class grades. Additionally, we are asking the student to learn a new testing strategy during their specialized instruction time and utilize the strategy while taking course exams. We would also like each student to participate in an interview about the strategy that will take about 30 minutes and will be conducted by a research assistant from outside the school district. The research assistant was a classroom teacher in an independent school for ADHD students and now serves as an administrator in the same school.

All data we collect will be strictly confidential (see consent for more details), and your participation in this study is completely voluntary. If at any time during the study you or your child choose not to participate, you may opt out with no penalty to you or your child.

If interested in participating, please click on the link in the email, select “I consent”, and submit.

Thank you in advance for your consideration and please feel free to contact me if you have any questions about this research.

Respectfully,

/S/ Brent A. Jones

Brent A. Jones
East High School Social Studies Teacher
bjones90@jhu.edu
(484)-266-3800

Dr. Christine Eccles, Principal Investigator
Assistant Professor, School of Education | Johns Hopkins University
Appendix I

Assent Form for the Intervention Study

Johns Hopkins University
Homewood Institutional Review Board (HIRB)

---

## Assent Form

<table>
<thead>
<tr>
<th>Title:</th>
<th>A Cognitive Load Reduction Program for High School Students with Attention-Deficit/Hyperactivity Disorder (ADHD): A Single-Subject, Mixed Methods Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Investigator:</td>
<td>Dr. Christine Eccles, The Johns Hopkins University School of Education</td>
</tr>
<tr>
<td>Date:</td>
<td>July 31, 2018</td>
</tr>
</tbody>
</table>

We want to tell you about a research study we are doing. A research study is a way to learn more about something. We would like to find out more about strategies that students can use to help improve their academic performance. You are being asked to join the study because you were identified as a student with Attention-Deficit/Hyperactivity Disorder (ADHD) and you have an Individualized Education Program (IEP).

If you agree to join this study, you will be asked to complete five online Schoology lessons that will take approximately 20-30 minutes. We would like you to use the strategy learned during the lessons whenever you take a test and let us know how it worked during a short interview of about 30 minutes.

We do not know if being in this study will help you. We expect that the study will help you by providing a strategy to remember multiple things at one time as you are often asked to do during tests and classroom instruction. We may learn something that will help other high school students with students with ADHD soon.

You do not have to join this study. It is up to you. You can say okay now and change your mind later. All you have to do is tell us you want to stop. No one will be mad at you if you don’t want to be in the study or if you join the study and change your mind later and stop. None of your teachers, other than your special education teacher, will know if you are in the study or decided not to be in the study.

Before you say yes or no to being in this study, we will answer any questions you have. If you join the study, you can ask questions at any time. Just tell your special education teacher and they can ask the researchers for you.

If you want to be in this study, please sign your name. You will get a copy of this form to keep.

---

Sign your name here    Date
Appendix J

Interview Questions

A Cognitive Load Reduction Program for High School Students with Attention-Deficit/Hyperactivity Disorder (ADHD): A Single-Subject, Mixed Methods Study

Brent A. Jones

Fidelity of Implementation of Lesson

1. During the second marking period, you completed five online lessons on Schoology about a testing strategy called Cognitive Load Reduction. How did you know when to access the lessons?

2. Please explain if you needed any help from your teacher when completing the online lessons.

3. Do you believe the online lessons helped you learn the strategy?

4. Do you think you would have learned the strategy better or worse from an instructor with you in the classroom? Why?

5. How soon after completing the lessons did you begin using the strategy on tests or in the classroom?

Fidelity of Implementation of Testing Strategy

1. How often do you take classroom tests in an alternative testing environment? Do you typically utilize an extended time accommodation?

2. After learning the cognitive load reduction strategy, were you provided a memory aid of strategy to use each time you took a test in an alternative testing environment? If so, did you find the memory aid helpful? Please explain.
3. When did you find the strategy most useful? Were there certain types of questions on tests such as multiple choice or essay that it was easier to use it? Why?

4. Were there any subjects that were easier to use the cognitive load reduction strategy? Why?

5. I am going to give you a few test questions and the memory aid. Can you show me and talk me through how you used it. Please read it aloud first. (note to the interviewer. They do not have to answer question 1. Just ask them to explain how they would prepare to answer it.

Student Perceptions of the CLRP

1. How useful did you find the CLRP?

2. How often did you use it when taking tests?

3. Did you find yourself using it in other situations in school when you were not taking tests? Please explain.

4. Do you think other students should learn this strategy? Why or why not?

5. Do you believe you became a better student as a result of the CLRP? Why or why not?
Brent A. Jones  
310 Bailey Road, Bryn Mawr, PA 19010  
(610) 256-1673  
bjones90@jhu.edu

Education:

Johns Hopkins University, Baltimore Maryland  
Doctor of Education June 2019, GPA 3.9  
Concentration: Mind, Brain, and Teaching  
Dissertation Title: The Underachievement and Performance of High School Students with Attention-Deficit/Hyperactivity Disorder  
Committee: Carey Borkoski, Christine Eccles (Chair), Mary Ellen Lewis

Neumann University, Aston, PA  
Master of Science - Educational Leadership, July 2005, GPA 3.9

Franklin & Marshall College, Lancaster, PA  
Bachelor of Arts, May 2001, GPA 3.0  
History Major

Millersville University, Millersville, PA  
Pennsylvania Secondary Social Studies Instructional I Certification, May 2001

University of Essex, Colchester England  
Semester Abroad, Fall 1999

Immaculata University, Fraser, PA  
9 graduate credits in School Psychology, Summer and Fall 2002

Teaching Experience:

Teaching Assistant, Johns Hopkins University, Baltimore, MD  
2018  
Course: Disciplinary Approaches to Education in the EdD program  
• Created worked examples instructional videos on academic writing and APA format.  
• Worked one-to-one with students supporting their learning in various topics such as the academic disciplines, research methods, and analyzing research articles.  
• Monitored all discussion board posts and pushed students’ thinking through questions and alternative ideas.

Social Studies, West Chester East High School, West Chester, PA  
2004-Present  
Courses:  
Advanced Placement Psychology  
• Topics include developmental psychology, learning, cognition, neuroscience, and research methods
+400 students received college credit based upon AP exam scores

Western World History
- Topics cover Ancient to Modern Times
- Led a team of teachers to redesign the curriculum for horizontal and vertical alignment from grades 6-12
- Led a team of teachers to align the curriculum with PA State Standards
- Assisted in the creation of common formative assessments
- Member of the textbook review committee

American History
- Reconstruction until the 1990s
- Assisted in the creation of common formative assessments

Sociology
- Developed the course and wrote the curriculum
- Topics include the sociological approach, research methods, major theories

Global Studies, Coatesville Senior High School, Coatesville, PA 2001-2004
Courses: Western Civilization, Afro-Asian Cultures

Research Experience:

Doctoral Researcher, Johns Hopkins University, School of Education
- Applied dissertation addressing a problem of practice in my context
- The dissertation includes 1) an extensive literature review of factors contributing to the underachievement of ADHD students, 2) a needs assessment study of those factors in my context, 3) a literature review of potential solutions that primarily focuses on ADHD students’ working memory deficits, and 4) a mixed methods intervention study.

School District Professional Development Presentations:
- “WCASD Local Assessments: How to Write and Incorporate Local Assessments for the Behavioral Sciences” August, 2018
- “Using Data to Examine Cultural Bias in Course Exams” November, 2017
- “Tech Tips for Teachers” 2015-2017

School District Committees:
- Local Assessments Committee: Examined research-based assessment frameworks, wrote a school district mission statement, provided feedback on the creation of a visual diagram of the system, developed timelines for implementation, and assisted in the creation of the PD for teachers
-**Comprehensive Plan: Innovation in Teaching and Learning Subcommittee** - Assisted in the creation of a three year plan for the school district that included goals, actions steps, and the data needed to evaluate the achievement of the goals

-**Technology Integration Team** : Researched best practices, created district plans, developed online PD courses, and trained teachers

-**Course Management System Selection** : Presented the features, drawbacks, and benefits of Moodle. Helped select Schoology as the course management system for the district after meeting with various vendors and comparing the systems to Moodle.

-**Blended Learning** : Piloted the first school district blended learning class, collected data to evaluate its success, helped facilitate an MOU between the union and school district based on my experiences teaching the class, helped develop a plan for future courses.

-**AP Summer Boot Camp** : Developed the goals and curriculum for an AP Summer Boot Camp for students. Taught the pilot course.

-**Curriculum Mapping Core Team** : Selected as a teacher leader of curriculum mapping, led PD sessions, oversaw the creation of curriculum maps for all high school social studies courses.

**Honors/Achievements:**

- **Dean’s List** - Fall 1997, Spring 1999, Spring 2000
- **Delphic Society** - Franklin & Marshall’s academic/athletic honor society
- **Viking with Pride Award** - Awarded to the teacher that best represents East High
- **Teacher of the Month** - First teacher nominated and selected by the students

**References:**

Carey Borkoski, Ph.D., Ed.D.
Assistant Professor, Johns Hopkins University School of Education
[cborkoski@jhu.edu](mailto:cborkoski@jhu.edu)

Christine Eccles, Ph.D., Ed.M.
Visiting Assistant Professor, Johns Hopkins University School of Education
[ceccles2@jhu.edu](mailto:ceccles2@jhu.edu)

Mary Ellen Lewis, Ed.D.
Visiting Assistant Professor, Johns Hopkins University School of Education
[mebl@jhu.edu](mailto:mebl@jhu.edu)