THE IMPACT OF WORKING MEMORY ON STUDENTS TESTED FOR SPECIAL EDUCATION SERVICES

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Abstract

Researchers, such as Dehn (2008), Alloway (2008), and Pickering and Gathercole (2004), have studied the impact of working memory on learning. During this study, the researcher adds to their knowledge by studying the impact of *Working Memory* and the other WISC index categories, *Verbal Comprehension, Perceptual Reasoning, and Processing Speed*. These four index scores were examined to determine if one was significantly different than the others and impacted learning more frequently.

This quasi-experimental, quantitative-research study included a sample of 188 students between the ages of 6 and 16 who were referred for special education services and who were given the WISC-IV during their evaluation. There were four groups analyzed during this study. The first group consisted of the entire sample of 188 students referred for special education testing. The second group comprised of the students who did not qualify for a disability under Missouri criteria. The third group contained students who qualified for a Specific Learning Disability under Missouri criteria. In the fourth group, the gender differences of the students who qualified for a Specific Learning Disability were examined across the four WISC-IV index scores.

One-factor ANOVAs were utilized to address research questions one, two, and three and a two-factor ANOVA was conducted for research question four. Tukey honestly significant differences were utilized to further analyze the significance of the interaction effects. Additional analyses were conducted to determine if the examiner's scores were statistically significant from one another.

The findings of the study revealed that students who were tested for special education services are impacted by working memory and processing speed. Students

who did not qualify for a disability were not impacted by any index category. Students who qualified for a Specific Learning Disability were impacted by the *Processing Speed* index score, but the *Working Memory* index score was slightly significant as well. Gender differences influenced *Verbal Comprehension, Perceptual Reasoning*, and *Processing Speed* index scores.

Dedication

This dissertation is dedicated to my grandma, "Gram." Since I was a little girl, you preached the importance of getting an education. You explained to me how your education provided you opportunities you would not have had otherwise. You also created a vision for me that even I could not comprehend. Even when I did not think I could or would want to get my doctorate, you believed in me and motivated me to try. You have continued encouraging me throughout this difficult journey. Thank you for your love and support. I love you.

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Chapter One

Introduction

Across America, students struggle to meet grade-level expectations even though teachers and other professionals intervene constantly on their behalves. Statistics show that students are not progressing in reading as they should. In Missouri public schools, for instance, 64 percent of fourth-grade students lack reading proficiency; and according to the most recent National Assessment of Educational Progress (NAEP), "nationally, the percent of fourth graders scoring below proficient reading level [is] 68 percent" (Thornburg, Harris, & Hawks, 2011, p.1). These statistics show that significant numbers of students are failing to keep up with their peers or are unable to advance in general education settings.

Such poor academic progress motivates teachers to refer students to special education programs. Among the choices teachers have for identifying students' learning problems are their categorization as "slow learners" or "slow processors." According to the National Joint Committee on Learning Disabilities, distinguishing between slow learners and persons who are learning disabled is "often difficult, based on observed behaviors" (LDOnline, 2010, p.1). Not surprisingly, then, teachers may not know what to look for to determine whether students have learning disabilities. Some teachers equate learning disabilities with low intelligence-quotient scores or working slowly in the classroom. Researchers Tracy Alloway (2008b), Susan Pickering (2006), and Susan Gathercole (2004) believe that deficiencies in working memory could be the cause of such learning disabilities. Alloway and Gathercole (2011) define working memory as "the ability to hold information in [the] brain and manipulate it mentally" (p. 1).

Therefore, researchers could potentially study the impact of working memory on students who are referred to special education programs and who qualify for learning disabilities. Through this research, the impact of working memory may be seen as more prevalent in our struggling learners. If this is the case, teachers may come to better understand how to program for struggling students prior to a special education evaluation.

Background Information of the Study

In this section, the researcher will explain the background information of the ABC School District. First, the demographics will be introduced including the number of students, number of schools, ethnicity of students, number of students in special education programs, and the disabilities found in the ABC School District. Second, the Response to Intervention process will be explained, and third will be an introduction to working memory.

Background Information about the ABC School District.

The ABC School District, a suburban Missouri K-12 school district, was the location of the study. For the 2009-2010 school year, the district enrolled 8,720 students in two early-childhood centers, ten elementary schools, three middle schools, two high schools, two alternative schools, and one career center. The early-childhood centers served children from three to five years of age; the elementary schools took students from kindergarten through fifth grade; the middle schools had students from sixth through eighth grade; the high schools accepted students from ninth through twelfth grade; the alternative schools attended to kindergarteners through twelfth graders who have conduct and emotional disorders; and the career center worked with tenth through twelfth-grade students who chose technical career paths.

In the ABC School District, the Caucasian student population has steadily decreased from 56.4 percent in 2005 to 45.4 percent in 2009. During the same timeframe, the African-American student population increased from 36.9 to 45 percent (Table 1), and the percent of Hispanic students grew from 4.7 to 7.2. The percent of students who received free and reduced-price lunches rose from 39.7 in 2005 to 49.4 in 2009.

Table 1

ABC School District Demographic Data 2005-2009 in Percentages

Year	*2005*	*2006*	*2007*	*2008*	*2009*
Asian	1.4	1.5	1.9	1.9	1.5
Black	36.9	39.6	41.1	42.8	45.0
Hispanic	4.7	5.3	6.1	6.7	7.2
Indian	0.5	0.5	0.4	0.4	0.4
White	56.4	53.1	50.4	48.1	45.4

Note: From "Demographic Data 2005-2009," by Missouri Department of Elementary and Secondary Education School Data and Statistics, 2009a.

The number of students who qualified for special education services decreased from 2005 to 2009. A total of 1,143 students received special education services in 2005, 1,085 in 2006, 1,086 in 2007, 1,048 in 2008, and 1,112 in 2009. (Department of Elementary and Secondary Education, 2005, 2006, 2007c, 2008b, 2009c). During the 2009-2010 academic year, 50% of students in special education programs were Caucasian, 48.08% were African-American, and 1.92% were Hispanic. Of the students who qualified as having Specific Learning Disabilities, 44.78% were Caucasian, 47.55% were African American, 5.97% were Hispanic, 1.49% were Asian, and 0.21% were Indian.

Table 2

ABC School District Percentage of Students Who Qualify for Special Education by Race/Ethnicity during the 2009-2010 School Year.

Disability Area	White	Black	Hispanic	Asian	Indian
Other Health Impairment	43.17	46.91	7.56	1.98	0.38
Autism	49.50	42.82	6.05	1.45	0.18
Mental Retardation	40.43	55.32	3.19	1.06	0.00
Emotional Disturbance	59.30	39.53	0.00	1.16	0.00
Speech/Language Impairment	56.39	33.04	8.37	1.76	0.44
Specific Learning Disability	44.78	47.55	5.97	1.49	0.21
Students in special education programs	50.00	48.08	1.92	0.00	0.00

Note: From "Percent of Students by Race/Ethnicity (SPP 9/10)," by Missouri Department of Elementary and Secondary Education Special Education District Profile, November 2010.

In this section, demographic information was explained. Next, information about the district as a system is explained. This additional information describes the Response to Intervention (RtI) framework used in ABC School District. The information about RtI helps clarify the process used to identify students to be referred for special education.

Response to Intervention (RtI).

In order to meet the needs of struggling students, schools have adopted the Response to Intervention (RtI) model. RtI is a system of supports for students who are not meeting grade-level expectations. The system is designed to meet the needs of all students, starting with the least restrictive and progressing to the more-restrictive interventions (Klotz & Canter, 2007). This process emphasizes "how well students respond to changes in instruction" (Klotz & Canter, 2007, p. 1). If a student who is struggling with a learning area receives more instruction and responds by improving in the targeted area, teachers can assume that the intervention worked. If the child does not respond to such additional instruction, achieving progress may require another type of intervention (Buffam, Mattos, & Weber, 2009, p. 93).

The ABC School District utilizes RtI to provide interventions to struggling students before they get too far behind their peers and to identify which students to evaluate for inclusion in special education programs. The ABC School District begins by providing interventions through RtI to the students who need them. Students who do not respond to the change in interventions over an extended period may need to be referred for special education qualification. Through the RtI process, school professionals can ensure that discrepancies between ability and performance are not linked to a lack of instruction in reading or math (Special Education Coordinator, personal communication, February, 2011).

Working memory.

The use of memory affects the way students progress through school and continues to have a significant effect on them throughout their lives. Memory is the "encoding, storage, and retrieval in the human mind of past experiences" (Wesson, 2011, p. 1). Every day, massive amounts of information pass through people's brains and they must articulate, manipulate, and remember. In the 1890's, William James studied memory and observed two types: primary (short-term) and secondary (long-term) (as cited in Thorn & Page, 2009, p. 1). Years later in 1974, other scientists agreed with the concept of two separate memory systems; but Baddeley and Hitch proposed that those systems interacted by moving information from short term to long term memory (Baddeley, 2004, p. 3). In 1974, Baddeley and Hitch also proposed another memory system that they christened "working memory" (as cited in Baddeley, 2008). Working memory is associated with multi-step tasks as well as analytical and higher-level thinking tasks and attention (Baddeley, 2004, p. 3).

The notion that active thinking takes place in working memory leads us naturally to conclude that learning is contingent on it as well (Wesson, 2011, p. 1). For decades, researchers have studied the effects of working memory on learning, and some of them believe working memory to be imperative for students' success at school (Alloway, 2008c, p. 1). Being successful in school often requires students to gain information from their teachers, manipulate that information in some way, and produce answers or some type of work product. This idea coincides with the definition of working memory from McGrew and is supported by many researchers. Breznitz and Share stated in 1992 that they believe that having a good working memory is necessary for learning to read (as cited in Vockell, 2011, p. 1). Klingberg (2009) thinks that working memory "is used to control attention, to remember instructions, to keep in mind a plan of things to do, and to solve complex problems" (p. 45). All of these examples can be referenced in a school setting and will impact the learning process.

Professionals can use the Wechsler Intelligence Scale for Children-IV (WISC-IV) to determine students' intelligence quotients. District test examiners administer the WISC-IV to the students in ABC School District who are being tested for special education. The WISC-IV assessment provides the test examiners with four index scores—*Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed*. The test examiners use these index scores to compute the Full Scale Intelligence Quotient (IQ) and, by looking at the scores, can identify students' strengths and weaknesses (Wechsler, 2003, p. 53).

Statement of the Problem

Tracy Alloway (2008c) regards "working memory [as] the best predictor of academic success" (p. 1). She has argued that working memory capacity determines the ability to learn more than does the overall intelligence-quotient assessment (2008c, p. 1). Currently, educators in the ABC School District do not know if working memory significantly affects students who are referred to special education programs (Test Examiner G, personal communication, Dec. 2010). Prior to students taking the WISC-IV, it is unclear as to which IQ index score is the lowest.

Significance of the Study

Currently, the number of students with low working memory capacities who are referred for special education programs has not been analyzed in the ABC School

District. Once educators know which is the most significant factor impacting the learning of students referred for special education programs and those who qualify for Specific Learning Disabilities, educators will potentially have a greater understanding of how to support these students. This information could equip educators to better meet students' needs and help them focus on finding working memory improvement programs, such as *Jungle Memory*, which in turn would improve students' academic progress (Alloway, 2010, p. 1). Knowing whether or not the *Working Memory* index score was a significant factor allows teachers to address the other areas of the WISC-IV—*Verbal Comprehension*, the ability to comprehend and respond correctly to what is said or asked, *Perceptual Reasoning*, the ability to reason and manipulative items nonverbally, or *Processing Speed*, the ability to work quickly. Once the teacher knows which area is impacting the child's learning or which area may be the root cause of the child's difficulty in school, the teacher can address how to support the child academically.

Purpose of the Study

Four objectives were addressed in this study. The first was to determine whether students referred for special education programs exhibit working memory deficits that impact their academic achievement; the second was to determine whether students who qualify for Specific Learning Disabilities have working memory deficits; and the third was to determine whether students who do not qualify as having disabilities have working memory deficits. The last objective was to determine if the gender of the students who qualify for Specific Learning Disabilities under Missouri criteria affects their *Working Memory* index scores.

Delimitations

According to Lunenburg and Irby, delimitations are "self-imposed boundaries set by the researcher on the purpose and scope of the study" (2008, p. 134). This study had the following delimitations:

1. All of the students used in this study were referred for special education services due to a suspected disability.
2. All of the students used in the study attended ABC School District when they were evaluated for special education services.
3. All of the students were evaluated during the 2009-2010 school year.
4. The students participating in the study ranged age 6 to age 16.
5. Only students evaluated using the Wechsler Intelligence Scale for Children-IV were included in this study.

Assumptions

The researcher assumed that all special education process coordinators and special education teachers followed the process for special education evaluation as laid out by the state of Missouri and the ABC School District. A second assumption was that examiners administered the Wechsler Intelligence Scale for Children, Fourth Edition, according to the administering booklet and scored it appropriately. In addition, all special education process coordinators followed Missouri eligibility criteria for determining the qualification for a Specific Learning Disability, as well as the qualification for other disabilities.

Research Questions

The following research questions guided the study.

1. For students who are referred for special education, to what extent is working memory a major deficit area?
2. For students who do not qualify under Missouri criteria for any special education diagnosis, to what extent is working memory a major deficit area?
3. For students who qualify for a Specific Learning Disability under Missouri criteria, to what extent is working memory a significant factor in the diagnosis of a learning disability?
4. Of the students, who qualify for Specific Learning Disabilities under Missouri criteria, to what extent are *Working Memory* index scores affected by gender?

Definition of Terms

Diagnostic Teaching. "An explicit teaching time (up to 2 hours daily) with a special-education teacher during a special education evaluation. Parental consent for the evaluation must have been signed prior to beginning diagnostic teaching" (ABC Curriculum Handbook, p. 17).

Discrepancy Model. "A measure to determine how far children have fallen behind their peers" (On-Track Reading, 2008).

Perceptual Reasoning Index Score. "A measure of [a] student's ability to interpret and/or organize visually perceived material" (Nicholson & Erford, 2006, p. 6).

Processing Deficit. "Problems with the processes of recognizing and interpreting information taken in through the senses" (WETA-TV, 2010).

Processing Speed. "The ability to automatically and fluently perform relatively easy or over-learned cognitive tasks, especially when high mental efficiency (i.e., attention and focused concentration) is required" (McGrew, 2003).

Progress Monitoring. "Progress monitoring is a scientifically based practice that is used to assess students' academic performance and to evaluate the effectiveness of instruction. Progress monitoring can be implemented with individual students or an entire class" (National Center on Student Progress Monitoring, (2008), p. 1).

Response to Intervention (RtI). "Response to Intervention (RtI) is the practice of providing high-quality instruction and interventions matched to students' needs, monitoring progress frequently to make decisions about the changes in instruction or goals, and applying child-response data to important educational decisions" (National Association of State Directors of Special Education, Inc., 2006, p. 3).

Special Education Process Coordinator. "[A] special education staff member who supervises special education staff in each building [and] assists with compliance and educational progress of students" (ABC Curriculum Handbook, p. 17).

Special Education Programs. Students who qualify to participate in special education programs by being evaluated for special education and who meet the criteria for one or more of thirteen eligibility areas: Autism, Hearing Impairment/Deafness, Emotional Disturbance, Language Impairment, Mental Retardation, Multiple Disabilities, Other Health Impaired, Orthopedic Impairment, Specific Learning Disability, Articulation/Phonology/Speech, Traumatic Brain Injury, Visual Impairment/Blindness, and Young Child with a Developmental Delay. (DESE, 2008a)

Specific Learning Disability. According to the State of Missouri Guidance for Identification Of Specific Learning Disability, a specific learning disability is defined as "a disorder in one of more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations" (DESE, 2008a, p. 1).

Universal Screening. "A step taken by school personnel early in the school year to determine which students are 'at risk' for not meeting grade-level standards or those who have behavioral or emotional problems that may interfere with their learning" (Klotz & Canter, 2007, p. 1).

Verbal Comprehension Index Score. The measure of students' abilities to reason verbally, comprehend information, and verbally express themselves (Wechsler, 2003, p. 4).

Wechsler Intelligence Scale for Children, Fourth Edition. "Identifies key cognitive strengths and weaknesses related to learning disabilities, executive function, attention disorders, TBI, intellectual disability, and giftedness" ("Critical Clinical", 2010).

WISC-IV Index Scores. WISC-IV index scores are "derived from a combination of selected subtests" (Nicholson & Erford, 2006, p. 4). "The WISC-IV yields four index scores: *Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed*" (Nicholson & Erford, 2006, p. 4).

Working Memory. "Ability to temporarily store and perform a set of cognitive operations on information that requires divided attention and the management of the limited-capacity resources of short-term memory" (McGrew, 2003, p. 1).

Overview of Methods

A quasi-experimental, quantitative-research design was utilized for this study to help determine if working memory deficits significantly impact students who are tested for inclusion in special education programs. The population for the study consisted of ABC school district students who were tested for disabilities under the realm of special education during the 2009-2010 school year. The researcher used archived district data for this study. The data was inputted into the SPSS PASW 18.0 and analysis of variance was used to address the research questions.

Summary and Organization of Study

This study is organized into five chapters. Chapter one includes the background of the study, the significance of the study, statement of the problem, purpose of the study, delimitations, assumptions, research questions, and definitions of terms. Chapter two is a review of the literature, which includes the history of special education, the history of intelligence testing, the history of the Wechsler Intelligence Scale for Children, Fourth Edition, an overview of RtI, qualifications for special education, description of working memory, and working memory interventions. Chapter three is a description of the methodology used in the research and includes the research design, population and sample, sampling procedures, instrumentation, measurement, validity and reliability, data collection procedures, data analysis and hypothesis tests, and limitations. Chapter four is a presentation of the study's findings, including descriptive statistics, hypothesis testing, and additional analyses, and chapter five consists of an overview of the study, major findings, conclusions, implications for action, and recommendations for future research.

CHAPTER TWO

Review of the Literature

In this chapter, the researcher explains the literature associated with working memory and special education qualification. First, the history of intelligence testing is provided along with an explanation of its relationship to the history of special education in American schools. Second, background information is presented about Response to Intervention and how it has impacted the qualification process for special education programs. And third, working memory is examined and its role in school achievement is analyzed.

History of the Study of Intelligence and of Intelligence Testing

Human intelligence is a complex topic that investigators have studied for hundreds of years. Researchers continue to argue about how to measure intelligence, and they do not always agree on what IQ is or how to measure it (Oregon Technology in Education Council, 2008). As long ago as 2200 B.C., Chinese emperors used "large scale 'aptitude' testing for the selection of civil servants" (Machek, 2006, p. 1). In the early 1800's, Germany's Wilhelm Wundt began to study intelligence differences in individuals, and Jean-Marc Gaspard Itard began to create educational programs, including one of the first foam board puzzles (Tulsky, Chelene, Iynik, Prifitera, Saklofske, Heaton, Bornstein, & Ledbetter, 2003, p. 8). Edouard Seguin used information he gained while studying with Itard to form experimental classrooms, and he created a foam-board puzzle that allowed scientists to determine intelligence by measuring how quickly someone could piece together a puzzle (Tulsky et al., 2003, p. 8).

During this time, lay people viewed mentally handicapped persons as having mental illnesses, and they referred to them as lunatics (Tulsky et al., 2003, p. 8).

At the end of the 19th century, other scholars and scientists added to the school of thought by continuing to study human intelligence. Sir Francis Galton, of London, England, attempted to use motor coordination and sensory discrimination to determine a person's intelligence, but his attempts were unsuccessful (Machek, 2006, p. 1). Beginning in the 1870's, Harvard professor William James began teaching a psychology class, and his preparation and investigation were the beginning of the study of intelligence as we know it today (White, 2000, p. 2).

Although some of these ideas were later refuted, the information influenced other scientists, including James McKeen Cattel, who in 1890 created the Mental Tests and Measurement assessment, which was essentially an IQ test (Tulsky et al., 2003, p. 12). Columbia College and Columbia College of the Mines used this assessment as an entrance examination (Tulsky et al., 2003, p. 14). This exam focused on students' processing speed. The belief was that students who could complete tasks quickly had higher intelligence and could absorb more information (Tulsky et al., 2003, p. 14). At that time, many psychologists accepted Cattel's views, with the exception of James Mark Baldwin, who retained doubts about such practices. Other scholars, including Stella Sharp and Joseph Jastrow, began to promote the use of the IQ scales that Binet was developing (Tulsky et al., 2003, p. 14). Although Cattel's assessment was not recognized as truly measuring intelligence, processing speed is a component of modern-day IQ testing (Tulsky et al., 2003, p. 14).

In 1905, Alfred Binet and Theodore Simon produced the first intelligence test and christened it the "Measuring Scale for Intelligence" (Machek, 2006, p. 1). Their first intelligence test was used for the classification of "relatively low-functioning retarded children" (White, 2000, p. 6). According to Tulsky et al., Binet was interested in selecting tasks "that could help the French school system identify children for special education" (2003, p. 17). Because they created the test for mentally retarded persons, Simon and Binet did not make it difficult enough for average thinkers. In 1908, Simon and Binet extended the range of the assessment and decided to group their test takers by age level, thus introducing the concept of "mental age" (Boake, 2002, p. 4). The notion behind mental age was that "intellectual ability could be measured and that it increased progressively with age" (Wechsler, 1958, p. 24). According to Boake, this version of the assessment contained verbal and nonverbal subtests, but the emphasis was on verbal skills (2002, p. 4). This scale was designed to deal with general intelligence and did not take into account the breakdown of skills, such as, memory, processing speed, attention span, and so forth (Tulsky et al., 2003, p. 19). Binet recognized problems with the test and believed it should only be used as one part of determining intellectual functioning (Tulsky, 2003, p. 17). By 1911, Binet had completed the last revision of his assessment, and he died soon thereafter (Kamin, 1974, p. 6).

Word about Binet's assessment spread quickly. By 1916, Terman had revised the American version of it and called it the "Stanford-Binet" (Kamin, 1974, p. 6). This new assessment was not limited to testing children. Terman "extended the scale to assess adult intelligence and presented a new total score called the 'Intelligence Quotient (IQ),' which is used today" (Tulsky et al., 2003, p. 19). Testing authorities used this assessment to place children in special classes, hide the disabled from society, reduce crime and delinquency, identify highly intelligent students, and assist in assigning students to grade levels (White, 2000, p. 6). The Terman assessment contained racial and socio-economic biases. Terman was vocal about his distorted views of people with mental deficits and stated that “heredity studies of ‘degenerate’ families have confirmed, in a striking way, the testimony secured by intelligence tests” (Kamin, 1974, p. 6). Although other researchers were adding to this knowledge base, the Stanford-Binet had become the standard for IQ testing in the United States (Tulsky et al., 2003, p. 19).

Around this same time, Henry Goddard began administering the Simon-Binet to immigrants to prove to society that immigration would not cause problems (Kamin, 1974, p. 16). In addition, Goddard helped acquire new knowledge about mental levels and revealed that the “new science [had] generated data of profound social significance, and in particular, it [had] invalided the arguments of gentlemen socialists” like Terman (Kamin, 1974, p. 8). Testers were using intelligence testing to weed people out of society based on individuals’ perceptions of them. Terman believed strongly in this method and stated that “if we [are to] preserve our state for a class of people worthy to possess it, we must prevent, as far as possible the propagation of mental degenerates” (Kamin, 1974, p. 11).

Intelligence testing continued to spread during World War I. The U.S. Army used the assessment to determine who would be fit for military service (Wechsler, 1974, p. 3), initially testing recruits using the Group Examinations Alpha and Beta IQ assessments (Wechsler, 1944, p. 14). The Alpha assessment was created for literate English speakers, and the Beta was intended for “the minority of recruits who were illiterate or nonproficient in English" (Boake, 2002, p. 390). When soldiers failed the group test, they were given the Stanford-Binet (Boake, 2002, p. 392). The use of IQ testing had little effect on the war, but civilians were disappointed with the soldiers' scores (Kamin, 1974, p. 17).

Around the same time, Robert Yerkes, from the American Psychological Association, and James Bridges revised the Alpha test to include a point scale (Boake, 2002, p. 393). A point scale refers to the test starting with easy items and gradually increasing in difficulty. This test, called the Individual Examination, was the main source for the creation of the Wechsler intelligence and memory scales (Boake, 2002, p. 393).

In 1917, after completing his master's degree, David Wechsler took a job in an army camp giving the Stanford-Binet scale to soldiers who had failed the Alpha and Beta group tests (Boake, 2002, p. 394). During this time, Wechsler began to notice inadequacies in the assessment and came to believe that some of the deficiencies found in individuals were due to a lack of education instead of a lack of intelligence (Boake, 2002, p. 394). While still in the army, Wechsler began studying with Charles Spearman and Karl Pearson (Wechsler, 1974, p. 6). Through working in the army giving the Stanford Binet and working with these other psychologists, Wechsler concluded that everyone was partially correct and that "he should merge the different viewpoints of Binet, Spearman, and Pearson…into a theory and framework that everyone could accept" (Tulsky et al., 2003, p. 26). Although this task was not an easy one, Wechsler worked assiduously to gain the acceptance of his peers (Tulsky et al., 2003, p. 26).

In 1932, Wechsler began working at the Bellevue Psychiatric Hospital in New York as the chief psychologist (Boake, 2002, p. 396). During this time, he created a test that was based on his definition of intelligence, which, in his terms, was “the capacity of the individual to act purposefully, to think rationally, and to deal more effectively with his environment” (Wechsler, 1944, p. 3). After working in the psychiatric ward, Wechsler believed more than ever in a need for an adult intelligence test (Boake, 2002, p. 396). Prior to this time, most of the data utilized was from school-aged children (Wechsler, 1944, p. 13).

The new assessment, which eventually became the Wechsler-Bellevue Scale, was a conglomerate of several different assessments. Wechsler used some of the army’s Alpha tests in his assessment, including “Information, Comprehension, Vocabulary, Picture Completion, Picture Arrangement, and Digit Symbol” (Boake, 2002, p. 397). In addition, he included Memory Span, Similarities, Arithmetical Reasoning, Block Design, and Object Assembly as subtests (Wechsler, 1944, p. 77). Wechsler believed Binet’s test overemphasized the assessment of verbal intelligence, so his test included verbal and non-verbal subtests (Boake, 2002, p. 396). He also felt the meaning of the IQ should be changed from mental age to a chronological-age-ratio score because of its “natural limit of applicability” (Wechsler, 1944, p. 21).

Wechsler designed the performance scale subtests utilizing work completed by Cornell and Coxe in 1934 (Kaufman, 2002, p. 68). In contrast to Binet’s assessment, Wechsler’s subtests did not include any memory tests. This was probably because he was creating the Wechsler Memory Scale and the Wechsler-Bellevue Scale at the same time (Boake, 2002, p. 397). The original Wechsler-Bellevue Intelligence Scale was published in 1939 and went through three revisions before an alternate form, the Wechsler Mental Ability Scale, was used during World War II (Wechsler, 1946). Since then, the Wechsler-Bellevue Scale has been revised three times (Wechsler, 1955, 1981, 1997) and is now known as the Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1955, p. iii). Wechsler went on to create more intelligence assessments--the Wechsler Memory Scale, the Wechsler Preschool and Primary Scale of Intelligence (WPPSI), and the Wechsler Intelligence Scale for Children (WISC).

Development of the Wechsler Intelligence Scale for Children (WISC).

The WISC was first published in 1965 (Wechsler, 1974, p. 19). According to Wechsler (1974), the WISC was an experimental assessment for determining whether a child was schizophrenic or non-schizophrenic (p. 19). The revised version of the WISC was published in 1974. According to Wechsler, the WISC "conceives of intelligence as an overall or *global* entity, that is, a multi-determined and multi-faceted entity rather than an independent, uniquely defined trait [and] avoids singling out any ability, however esteemed, as crucial or overwhelmingly important" (Wechsler, 1974, pp. 30-31). He explained that intelligence is not a type of ability but rather the way in which multiple abilities present themselves under different circumstances (Wechsler, 1974, pp. 30-31). Following his conclusions about ability, Wechsler chose to use a multitude of subtests to determine the intelligence quotient and thus obtain a more accurate picture of a subject. He also believed that "intelligence is best regarded not as a single, unique trait, but as a composite or global one" (Wechsler, 1974, pp. 30-31). Wechsler revised the WISC in 1991, and it became the WISC-III. This was the last test Wechsler helped write.

In 2003, shortly after Wechsler's death, the WISC-III was updated by the Pearson Company to WISC-IV. Although Wechsler was not alive for the completion of the WISC-IV, his name remains on the cover as the assessment's author. The WISC-IV was similar to the WISC-III, but was updated to reflect "current theory and practice of cognitive assessment in children, including increased attention to working memory and processing speed" (Wechsler, 2003, p.3). Like the WISC-III, the WISC-IV provides a full-scale IQ score as well as four composite index scores: *Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed* (Wechsler, 2003, p. 4). The WISC-IV has the same *Working Memory* subtests as the WISC-III and the WAIS-III (Dehn, 2008, p. 201).

Working memory subtests.

Three subtests comprise the *Working Memory* index score: Digit Span, Letter-Number Sequencing, and Arithmetic. The Digit Span subtest has two parts—the Digit Span Forward and the Digit Span Backward (Wechsler, 2003, p. 2). For Digit Span Forward, the examiner tells the student a series of numbers, and the student must repeat the numbers in the same order. This part of the subtest starts with two digits and increases in difficulty to nine (Wechsler, 2003, p. 88). The second part of the subtest is Digit Span Backward. For this part of the subtest, the examiner says a series of numbers, and the student has to repeat the numbers backwards. Like Digit Span Forward, the examiner begins with two digits, but this time increases the digits to eight (Wechsler, 2003, p. 89). During Letter-Number Sequencing, the examiner says a list of numbers and letters in random order, and the student must respond first with the numbers in counting order and then with the letters in alphabetical order (Wechsler, 2003, p. 129). The examiner begins with one letter and one number and increases to eight of each (Wechsler, 2003, p. 130). During the Arithmetic subtest, the examiner provides the student with a story problem, and the student must figure out the correct answer mentally in less than thirty seconds (Wechsler, 2003, p. 192).

Digit Span and Letter-Naming are the standard subtests for determining a *Working Memory* index score (Wechsler, 2003, p. 5). These two subtests definitely should be given, and including the third subtest, Arithmetic, is highly recommended (Wechsler, 2003, p. 27). According to the scoring guide, if all three subtests are given, the test examiner has the option of taking the top two scores if a single score lowers the overall score (Wechsler, 2003, p. 27). The intention of the *Working Memory* index score is to determine how well the student gains information, manipulates it, and produces the correct answer.

History of the Education of Children with Disabilities

Over the years, the education of children with disabilities has changed drastically. It wasn't until 1578 that Pedro Ponce de Leon, of Spain, engaged in the "first authenticated education of a handicapped person" (Winzer, 2003, p. 6). In the 17th century, pioneers from Europe expanded upon the idea by aiming to educate people with exceptionalities (Winzer, 2003, p. 6). Until the 1940's, society shunned people with disabilities. People with disabilities were housed in state institutions for the mentally retarded and mentally ill and their senses of well-being were in constant jeopardy (U.S. Department of Education, 2007).

Changes began to take place when a group of parents organized an advocacy group. In 1947, the American Association on Mental Deficiency held its first convention (Gibson, 2007, p. 1). The rise of the Civil Rights Movement in the 1950s encouraged parents to form more groups, including the United Cerebral Palsy Association, the

Muscular Dystrophy Association, and John F. Kennedy's Panel on Mental Retardation (Gibson, 2007, p. 1). After years of contention, Congress passed the *Education for All Handicapped Children Act (*Public Law-PL 94 - 142) in 1975. By creating this law, it was Congress' intention to protect and meet the needs of children with handicaps, support states and local areas in protecting their rights, and improve results for children with handicaps and their families (U.S. Department of Education, 2007). PL 94 - 142 allowed children with disabilities to attend public schools, receive proper evaluations, and be identified with the correct disability.

Although PL 94 - 142 was written to eliminate negative attitudes toward individuals with disabilities, the American government was aware of negativity and injustices towards individuals with disabilities, including a lack of protection in the workplace, housing, education, public access, etc. ("Weekly Compilation", 1990). In order to disseminate information about discrimination against individuals with disabilities, Congress passed the American Disabilities Act (ADA) in 1990. The ADA provided a specific national mandate to eliminate discrimination, implement standards, and enforce the fourteenth amendment ("Weekly Compilation", 1990).

PL 94 - 142 was amended in 1978, 1986, 1990, and 1997. In 1997, it became known as the Individuals with Disabilities Education Act (Stadler, 2007, p. 185) and provided rights to students with special needs and their families. The Individuals with Disabilities Education Act (IDEA) is a "law ensuring services to children with disabilities throughout the nation" (U.S. Department of Education, 2010). The rights specified in the law include the right to testing to determine eligibility and needs, the right to see school records, the right to attend annual Individual Education Program (IEP) meetings and be part of the written plan, and the right to due process (U.S. Department of Education, 2010). The law was reauthorized in 2004 by President George W. Bush. It was renamed the Individuals with Disabilities Education Improvement Act (IDEIA) and became effective in 2005. The IDEIA established more requirements for special education teachers stating that teachers must be "highly qualified" (U.S. Department of Education, 2010). This means that special education teachers must have bachelor's degrees, be certified to teach special education, and receive ongoing professional training (U.S. Department of Education, 2010). Also, the IDEIA raises expectations for identifying children for special education, outlines how IEPs are to be developed and reviewed, encourages the use of scientific, research-based interventions, and provides positive behavioral supports (Stadler, 2007, p. 186).

The IDEIA was constituted because of a new law—the No Child Left Behind Act-NCLB (2002). According to the NCLB, "The purpose of this title is to ensure that all children have a fair, equal, and significant opportunity to obtain a high-quality education and reach, at a minimum, proficiency on challenging State academic achievement standards and state academic assessments" (107^{th} Congress, 2002, p. 15). This means every child should be educated to [his or her] full potential and deserves improved teacher quality and effectiveness (107^{th} Congress, 2002, p. 135). Prior to this law, students with special needs took state assessments, but their scores did not count against the school. This new law would "increase accountability for student performance" (107^{th} Congress, 2002, p. 16). Schools would now be rewarded for students meeting expectations and would be sanctioned if students were not successful. All students were counted, including students in special education programs. Through the NCLB, IDEIA funds were increased to educate students with special needs (107th Congress, 2002, p. 388). The NCLB act has forced educators to focus on high levels of learning for all students instead of segregating students based on disabilities.

Response to Intervention.

Due to the tight constraints of NCLB and IDEA, Response to Intervention (RtI) was developed to ensure that educators intervene before students experience large learning gaps. The RtI philosophy is that all students can learn if provided with proper intervention and that educators must take responsibility for their students' learning (Buffum, Mattos, & Weber, 2009, p. 23). RtI is a tiered model designed to meet the needs of all students and is "a process that emphasizes how well students respond to changes in instruction" (Klotz & Canter, 2007, p. 1). It is a "multi-step approach to providing services and interventions to students who struggle with learning at increasing levels of intensity" (National Center for Learning Disabilities, 2006, p. 1).

The first step in the RtI process is to use universal screenings to determine where students are in the learning process. Universal screenings are tests given early in the school year which help "determine which students are 'at risk' for not meeting grade level standards" (Klotz & Canter, 2007, p. 1). The universal screenings help teachers, administrators, and literacy coaches become aware of students' performance and help them make educational decisions for students. Through this process, children are placed into one of three tiers of intervention. Students in Tier I receive instruction based on the school's core curriculum (Buffum, Mattos, & Weber, 2009, p. 31). These are the students who make adequate yearly progress using the general-education curriculum. Students in Tier II receive the general education curriculum and an additional intervention one to four times a week in the area in which they struggle (Buffum, Mattos, & Weber, 2009, p. 31). Students in Tier III are given more intensive support beyond that received by students in Tiers I and II. These students receive the general education curriculum and two additional interventions. Students who have qualified for special education services based upon Missouri initial criteria are sometimes considered to be in Tier III, or sometimes school districts create a fourth tier of intervention for them. RtI models can appear to be different, depending on the school, but the steps taken are similar.

The RtI process is intended to meet the needs of all students. Students who are not making progress should receive more support during the school day in the area of deficiency. Through constant analysis, teachers, coaches, and administrators should be able to monitor students' progress more effectively and provide them with proper support. Through the RtI model, students receive the interventions they need. According to *The Response to Intervention: A primer for parents*, RtI is "an array of procedures that can be used to determine if and how students respond to specific changes in instruction" (Klotz and Canter, 2007, p. 1). The process of RtI reduces the number of special education referrals for students who are tested and do not qualify due to early intervention.

Missouri's qualification process for Specific Learning Disabilities.

In order to qualify individuals as having educational disabilities in Missouri, each school district and agency must follow specific guidelines. Educators must follow specific criteria for students to be tested for disabilities. Prior to determining whether a child should be tested, school personnel must complete a review of existing data. During this process, a team of teachers, the principal, and the process coordinator collect data including "evaluations and information provided by the parents of the child, performance on current classroom-based assessment, performance on State and agency-aide assessment, classroom-based observations, and observations by teachers and related service providers" (DESE, 2007a, p. 2). After collecting the data and reviewing it with a team of school personnel and the parent, the team decides if it needs additional information, what data should be gathered, how the data will be compiled, and who will collect it. If the data are collected under the constraints of an evaluation, school personnel must obtain consent from the parent no later than thirty days past the original referral date (DESE, 2007a, pp. 2-3). After receiving parental consent, the team has 60 days to complete the formal assessments and meet with the parent (DESE, 2007a, p. 6).

When the team makes the decision about qualifying a student for a disability, it must follow specific guidelines according to Missouri state law. The law, as explained in the *Missouri State Plan for Special Education*, provides detailed definitions for determining eligibility of students with disabilities. Missouri follows the Individuals with Disabilities Education Act, which defines students with disabilities as "those children, ages three (3) to twenty one (21), who have been properly evaluated as having Mental Retardation, Hearing Impairments and Deafness, Speech or Language Impairments, Visual Impairments including Blindness, Emotional Disturbance, Orthopedic Impairments, Autism, Traumatic Brain Injury, Other Health Impaired, a Specific Learning Disability, Deaf Blindness, or Multiple Disabilities and who, because of that disability, require special education and related services" (DESE, 2007b, pp. 19-20). According to the Missouri State Plan (2007b), children do not qualify for disabilities because of a lack of reading instruction, math instruction, or English proficiency (p. 20). The Missouri Department of Education defines a student with a Specific Learning Disability as disordered "in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations" (DESE, 2007b, p. 24).

In order to qualify for a Specific Learning Disability under Missouri initial-eligibility criteria, a child must perform below grade level or "not achieve adequately for the child's age or meet State-approved, grade-level standards in one or more of the following areas: Oral Expression, Listening Comprehension, Written Expression, Basic Reading Skill, Reading Fluency Skills, Reading Comprehension, Mathematics Calculation, and Mathematics Problem Solving" (DESE, 2007b, p. 25). In addition, school personnel must be able to prove the student received learning experiences and instruction appropriate for the child's age or State approved grade level. This means that a lack of instruction in a particular area in which the child qualifies for a Specific Learning Disability is not the cause of the disability.

Missouri school districts must use scientific, research-based interventions prior to qualifying students as having disabilities. After receiving quality instruction and interventions, students must "exhibit […] pattern[s] of strengths and weaknesses in performance, achievement, or both, relative to age, state-approved grade-level standards, or intellectual development, that is determined by the group to be relevant to the identification of […] Specific Learning Disability[ies], using appropriate assessments, consistent with 34 CFR 300.304300.305" (DESE, 2007b, pp. 25-26). These patterns of strengths and weaknesses must provide a “severe discrepancy between academic achievement and intellectual ability of at least 1.5 standard deviations” (DESE, 2007b, p. 26). This means students’ intelligence-quotient scores must be at least 22 index points higher than their academic testing to be eligible for qualification. For example, Student A takes an intelligence assessment and obtains an index score of 100, which is considered average. In order to qualify as having a learning disability utilizing the discrepancy model, the academic assessment full-quotient score for this student must be a standard score of 77 or lower by at least two academic measurements in order for the student to qualify as having a learning disability. Students can qualify in one or more of the following eight academic areas: Oral Expression, Listening Comprehension, Written Expression, Basic Reading Skill, Reading Fluency Skills, Reading Comprehension, Mathematics Calculation, and Mathematics Problem Solving (DESE, 2007b, p. 25).

Districts are required to use data as part of the special education evaluation process to show that any discrepancies between students’ abilities and their academic achievements are not due to lack of instruction in reading or math (DESE, 2007b, p. 26). School personnel must produce data that demonstrate that:

- prior to or as part of the referral process the child received appropriate instruction in regular education settings,
- qualified personnel delivered the instruction,
- data-based documentation exists for repeated achievement assessments at reasonable intervals,
- the documentation reflects formal assessment of student progress during instruction, and

- the results were provided to the child's parents

  (DESE, 2007b, p. 26).

The Missouri State Plan allows the use of professional judgment when qualifying a student for a Specific Learning Disability under specific guidelines based on Response to Intervention (RtI). Under professional judgment, students do not have to meet the requirements for the discrepancy model, as long as the evaluation team concludes that a severe discrepancy exists based on specific data in the evaluation document (DESE, 2007b, p. 26).

Qualification process for special education in the ABC School District.

Beginning in 2008, the ABC School District began utilizing pieces of the RtI model (Special Education Process Coordinator, personal communication, October 2010). Currently, administrators and staff members in the ABC School District are refining the district's practices and collaborating to determine how best to meet the academic needs of all children in the district (Principal, personal communication, April 2011). RtI provides teachers with a strategic way to determine students' academic needs, meet those needs, and plan subsequent steps (Principal, personal communication, April 2011).

This model assists in determining which students may require specialized instruction. In the past, students received support, but no strategic method existed for implementing the process, and the type and number of interventions were not documented. (Special Education Process Coordinator, personal communication, October 2010). The competency of the regular educator and the decisions of the problem-solving team determined who was tested for special education qualification (Special Education

Process Coordinator, personal communication, October 2010). This process was subjective and did not utilize data.

Currently, ABC School District utilizes the RtI model to meet the needs of students when a problem area is identified. According to the *ABC Curriculum Handbook*, Response to Intervention is defined as “The practice of 1) providing high-quality instruction and interventions that match students’ needs and 2) using students’ learning rates over time and their levels of performance to make important educational decisions” (2009, p. 18). Response to Intervention is used in the ABC School District as a proactive approach to students’ learning processes and as an aid in determining who needs to be referred for special education testing (Literacy Coach, personal communication, October 2010).

All students are given a universal screening at the beginning of the year based on grade-level assessments. After taking the assessments, students are assigned to tiers based on their academic needs. Students in Tier I receive the general education core curriculum (ABC School District, 2009a, p. 17). They are students who do not require extra interventions throughout the day, because they are making adequate yearly progress as well as meeting or exceeding grade-level expectations without interventions. Students in Tier II receive the general education curriculum along with an additional two to five interventions per week above the support level provided in Tier I (ABC School District, 2009a, p. 17). Students in Tier III receive a general education curriculum along with Tier II interventions and an additional intervention three to five times per week (ABC School District, 2009a, p. 17). Tier III contains students who are most at risk for having learning problems. These students need a high amount of support to be successful. Students in

Tier IV have already qualified for special education attention and have an IEP. These students receive specialized instruction based upon their needs according to their special education evaluations (ABC School District, 2009a, p. 17).

Once students are placed into tiers based on need, they begin receiving core curriculum and additional interventions. They are given weekly or bimonthly progress tests to determine if their gains are generated by the interventions they are receiving (ABC School District, 2009a, p. 17). If students are not responding to the interventions, the interventions are modified or the number of interventions is changed. These decisions are based on each student's needs (Teaching and Learning Coach, personal communication, October 2010).

Once students are identified for Tier III interventions, the school principal, teaching and learning coach, special education process coordinator, special education teachers, and classroom teacher draft a Tier III plan (ABC School District, 2009a, p. 12). The classroom teacher then refers to the plan as a guide for compiling and analyzing information when making decisions about the student and their instruction. The plan contains informal data, ABC District assessment information, and, if applicable, state assessment information as well. The plan also shows the interventions used prior to the student's moving to Tier III. Lastly, the plan outlines the Tier III interventions that will be utilized. This plan is shared with the student's parent(s) and is reviewed after a month to determine if the student is making adequate progress (ABC School District, 2010b, p. 12). If the student is making progress, the team decides if the student still needs the high level of instructional support or if the student should move down to Tier II. If the student is not making progress, the team decides who will contact the parent about it (ABC School District, 2010b, p. 12).

When a student in Tier III shows minimal progress, the team may decide to refer the student for a special education evaluation (ABC School District, 2010b, p. 12). Once parental consent has been given, the student begins to receive diagnostic teaching by one of the school's special education teachers. Prior to beginning diagnostic teaching, the classroom teacher, literacy coach, process coordinator, school principal, and special education teachers meet to determine what specific skills need to be addressed. The team writes goals to be met within the next 24 days of diagnostic teaching (ABC School District, 2010b, p. 12).

After 24 days of diagnostic teaching and progress monitoring, the team reconvenes to determine if the student is making progress under the special educator's instructional plan (ABC School District, 2009b, p. 1). Students who have been placed in groups with intensive services for twelve weeks without progressing are examined more closely. The classroom teacher completes a social history with the parent to determine if any circumstances exist about which school officials did not know previously (ABC School District, 2009b, p. 1).

Then the special education teacher asks the school nurse to conduct a vision test to determine if the basis of the learning problem is perhaps poor vision. The speech and language pathologist administers hearing assessments to determine if hearing is a factor in the child's learning problem. If the child has known visual or hearing issues, an optometrist or an audiologist must perform an examination prior to the child being tested at school. Once hearing and vision problems are ruled out, the special education teacher completes a “Review of Existing Data” (ABC School District, 2009b, p. 1), which provides information about health, hearing, vision, intelligence, academics, communication, and motor skills. A Review of Existing Data helps the team determine if enough information exists to complete a full evaluation of a student’s educational needs (ABC School District, 2009b, p. 1).

Once the Review of Existing Data is compiled, the team determines if the student will be tested for a disability (ABC School District, Initial Referral and Eligibility, 2009). If the team members determine that they will proceed with an evaluation, they schedule a meeting with the parent to discuss the evaluation recommendation and obtain consent for testing (ABC School District, Initial Referral and Eligibility, 2009). At the same meeting, the group, including the parent, develops an evaluation plan, which provides a list of assessments in which the child will participate, along with a list of observations to be completed by school personnel. The concerns revealed on the Review of Existing Data should match the areas in which the child will be tested.

The team has 60 days to complete the evaluation. During this period, the evaluation team completes the testing and reviews it. The special education process coordinator meets with a building-level team and a district-level team to determine if the child is eligible for special education (ABC School District, Initial Referral and Eligibility, 2009). During this meeting, the staffing team “reviews [the] evaluation information and determines if the child has a disability as defined by Missouri eligibility criteria” (ABC School District, Initial Referral and Eligibility, 2009. n.p.). This is when the staffing team reviews and analyzes the assessments. The team helps determine if a processing deficit, such as working memory, processing speed, or sound-symbol relationships, impact the student's learning.

After the team determines the student's eligibility, it completes the evaluation report and schedules a meeting with the parent. At the evaluation meeting, the process coordinator explains the testing results. If the child qualifies for special education, the parent must decide whether or not the child should receive services. If the parent agrees with testing and would like the child to receive special education services, the team has 30 days to write the child's IEP and meet with the parents to initiate the IEP (ABC School District, Initial Referral and Eligibility, 2009).

Overview of Memory and Description of Working Memory

The way the brain processes, manipulates, and remembers information affects people's jobs, relationships, and experiences. Researchers have studied memory for over a hundred years. Although different theories exist regarding the elements of working memory, three main components are evident in all of them: encoding, storage, and retrieval. Baddeley, Kopelman, and Wilson (2004) define encoding as the way information is registered in the brain (p. 7). The brain receives information, processes it, and then determines what to do with it. These authors define storage as the way information is maintained over time. Once the information is encoded, the brain stores it for some period and retrieval as the way information is recalled later. Once the brain stores information, it must be able to find it. At times, the process is tedious; at other times, the brain retrieves the information quickly.

Although scientists have studied memory for hundreds of years, the study of the mind and memory became more prevalent in the 1960s when long-term memory (LTM) and short-term memory (STM) were viewed as separate systems (Baddeley, Kopelman, & Wilson, 2004, p. 1). In the late 1960s, Atkinson and Shiffrin proposed a memory model that can be viewed as a flow chart to help one understand the brain processes. The top of the chart begins with environmental input (as cited in Baddeley, Kopelman, & Wilson, 2004, p. 2). This means that the information is collected externally to the brain. Second are the sensory registers, and third is short-term memory. Sensory registers obtain the information and short-term memory stores the information for a minimal period of time. The person then uses information from short-term memory to produce a response or the brain moves the information to long-term memory (Baddeley, Kopelman, & Wilson, 2004, p. 2).

Alan Baddeley and Graham Hitch were concerned about Atkinson and Shiffrin's model and theorized that STM and LTM were interrelated. They confirmed their theory by conducting multiple experiments in which they "attempted to block STM in normal subjects by requiring them to recite digit sequences while performing other tasks, such as learning, reasoning, or comprehending, that were assumed to depend crucially upon STM" (p. 3). Next, Baddeley and Hitch declared there to be a more complex relationship between STM and LTM when the "impairment increased with the length of the digit sequence that was being retained" (p. 3). They termed this system "working memory". Working memory encompasses "an attentional controller, the *central executive*, assisted by two subsidiary systems, the phonological loop and the visuospatial sketchpad" (p. 3). Baddeley and Hitch's model is provided below in Figure 1.

The central executive is the main control for the memory system (Baddeley, 2006, p. 2). The phonological loop, also termed the articulatory loop, "is assumed to comprise a store that holds memory traces for a couple of seconds, combined with a sub-vocal rehearsal process" (Baddeley, Kopelman, & Wilson, 2004, p. 3). The sub-vocal rehearsal process is also referred to as sub-vocalization, which is the use of inner speech for rehearsing items in order to recall the information (Baddeley, 2006, p. 6). Lastly, the visuospatial sketchpad includes the storage of information and the visual and spatial manipulation of it (p. 4). Baddeley (2006) suggested that the sketchpad parallels the phonological loop but is not so easy to study (p. 13). He also aide the sketchpad "does not have a rich and standardized set of stimuli," but plays a vital role in obtaining visual and spatial information about the world (p. 13). For example, information that enters the brain goes into the central-executive part, is stored in the phonological loop, and heads back to the central executive area. In the visuospatial sketch-pad, this information is manipulated to produce a product that goes back to the central-executive part of the brain.

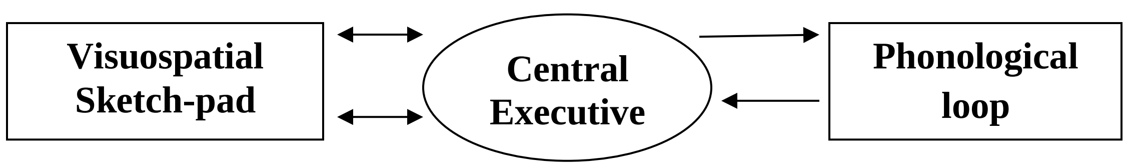

Figure 1. Working Memory Model.

Note. From "The Baddeley & Hitch model of working memory". Reproduced from Baddeley and Hitch (1974).

Baddeley teamed with Logie in 1999 and, by pointing to many test results that did not fit the previously suggested pattern. They began to think that "the central executive [was] purely an attentional system with no storage function[s]" (Baddeley, 2006, p. 23). Together they termed another component of working memory named the episodic buffer. The notion of the episodic buffer is that information connected with long-term memory is easier to manipulate, especially when it is chunked (Baddeley, Kopelman, & Wilson, 2004, p. 4). For example, reciting three important years in order is easier than reciting twelve numbers in a random order. Baddeley (2006) connects this idea with a previous model examined in 1956 by Miller, who christened the concept “chunking” (p. 23). After years of research, new findings generated a new model that linked the old model with long-term memory and the episodic buffer. This model is shown below in Figure 2.

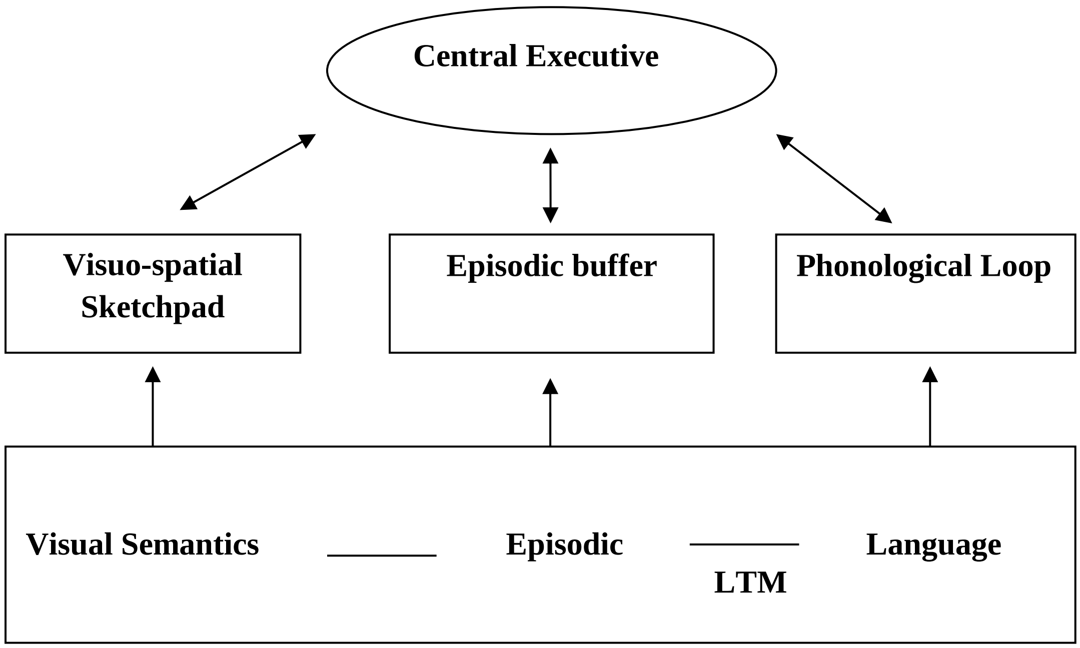

Figure 2. Multi-component Model of Working Memory.

Note. From “Working Memory: An Overview”. Reproduced from Baddeley (2006).

Executive skills in relation to working memory.

In order to complete higher-level thinking tasks, people need to use executive skills. Dawson and Guare (2004) describe executive skills as a way for humans determine the tasks to which they will pay attention, and they allow them to organize their thinking, plan for the future, maintain attention, analyze situations, make decisions, and monitor thoughts (p. 1). These skills include planning, organization, time management, working memory, and meta-cognition (p. 1). People are not born with these skills, but rather develop them over time, if the right circumstances are present.

One scientist, Barkley (1997), theorized a five-essential-elements model that begins at infancy (p. 191). The five elements include behavioral inhibition, working memory (nonverbal), self-regulation of affect/motivation/arousal, internalization of speech (verbal working memory), and reconstitution (p. 191).

For the purposes of this study, the researcher explained only the elements of working memory (nonverbal and verbal) because the main focus of this study was to determine if low working memory skills are inhibiting children from learning. According to Barkley (1997) “nonverbal working memory becomes the foundation for [a child]’s ability to make decisions and control behavior even though a person or an activity is not present here and now” (pp. 165-166). Therefore, nonverbal working memory helps people predict, remember, and mentally manipulate their thinking. Children who develop nonverbal working memory skills do so as babies. They are able to identify what they want when they are able to associate it with something else. Dawson and Guare (2004) call this speech internalization (p. 7). Speech internalization helps add to a person’s working memory by incorporating words and language. This skill begins to develop between ages 3 and 5 and “is largely [developed] by 9 to 12 years” (p. 7). Toddlers begin to think through tasks and will often verbalize their thinking. This skill continues to develop throughout childhood and eventually becomes fully internalized. Nonverbal working memory helps students solve problems.

Children who struggle with working memory deficits as related to executive skills struggle to make projections and plan. In order to make a plan, one must set a goal and keep it in mind. If working memory capacity is limited, it will be difficult for the student to keep their mind on the goal long enough to achieve it. “Even if the goals are retained long enough to establish plans, a 'leaky' working memory will results in quickly forgotten or poorly sequenced strategies and steps that will not or cannot be followed" (Kaufman, 2010, p. 7). This is why students with working memory problems struggle to complete goals. It is not due to being lazy or their willingness to care. It is because it is difficult for their brains to hold on to the information long enough to make a plan and follow through with the plans.

Executive skills can be taught with good modeling and modifications. Dawson and Guare (2004) suggest using a "developmental progression from external to internal" or concrete to abstract (p. 34). This means the adult needs to show the child his/her thinking by speaking their thinking aloud in steps. The child should learn how to process the information by listening to the adult think out loud. Once the skill is taught and practiced orally, the adult can gradually hand over responsibility to the child. The child can also learn to compensate for a lack of working memory skills by storing information in a planner or a computer so it is readily available when needed (p. 49). The child can also be prompted by verbal reminders, a watch alarm, or visual cues (p. 49). Dawson and Guare (2004) explain another way to support a child who has poor executive skills is to "think about ways to change the environment to adjust to their limitations" (p. 35). Once the child improves on the skill, the environment can slowly adjust back to the way it was, so the child can continue to improve. From there, children need to be able to generalize the skill to other situations and will need practice to do so (p. 35).

Many children who lack executive skills cannot apply the skills learned in one setting to another setting. Helping the child with the skill is the job of the parent and teachers.

Working memory as it relates to learning.

Working memory plays a role in whether or not a child becomes a successful learner. Alloway believes that "working memory is the foundation for learning at school" (2008b, p. 1). Teachers provide students with an abundance of information throughout every school day. Students must process the information, manipulate it, and decide what to do with it. For some students, this process is difficult. Alloway refers to working memory as a *box* and believes that most adults can hold three to five things in their minds at one time (as cited in Steenhuysen, 2008, p.1). Kauffman (2010) thinks that adults are able to hold up to seven items in their brain but only for about 20 to 30 seconds before part of the information escapes (p. 10). This is why remembering a grocery list of more than five items is difficult. One may be able to remember more than five items at first but once too many items are in the brain, the person is likely to forget at least one of them.

This is similar to a classroom situation, because at school teachers expect students to process a large quantity of information throughout the day. Some individuals are better at this than others. Some students are able to recall large amounts of information verbatim, while others struggle to remember one or two-step simple directions. Julie Steenhuysen (2008) believes that "defects in working memory—the brain's temporary storage bin—may explain why one child cannot read [a] history book and another gets lost in algebra" (p. 1). Even though these behaviors may make the student appear "slow" or "lazy," a working memory deficit may be the culprit.

Working memory can affect all subjects in school and is considered a "basic cognitive skill" that is needed in order to carry out tasks (Alloway, 2008b, p. 1).

According to Steenhuysen, students with working memory problems struggle to remember the content of a reading passage from beginning to end (2008, p. 1). Another researcher, Levine, gave the example of a little girl who said, "Every time I read a sentence it erases the one that was before it" (as cited in Steenhuysen, 2008, p. 1). This shows how defects in working memory can impact student achievement.

According to another Alloway (2008b) study, there is "one in ten students [with] poor working memory" (p. 2). In the United Kingdom, these numbers potentially equate to 500,000 children who are affected by problems with their working-memory (Lipsett, 2008, p. 1). This information was based on a study of 4,000 students between the ages of 5 and 18 (Alloway, 2008b, p. 1-2). Through this research, Alloway (2008b) determined that "working memory problems led to learning difficulties" for the students (p. 2). These students struggled with storing and processing information throughout their school day, specifically verbal and visual-spatial working memory problems (Alloway, 2008b, p. 2). According to Alloway, "working memory is the number one predictor of learning success" (p. 1). She believes that working memory is a better predictor than IQ scores or phonological skills. Alloway postulated it as a better predictor because it measures learning potential and is not linked to the environment or to socio-economic factors (as cited in Lipsett, 2008, p. 2). Through this research and the research of others, "scientists are suggesting that short-term or working memory is a better and simpler measure of the skills modern youngsters will need in school and their eventual careers" (Leake, 2009, p. 1).

Although research supports the impact of working memory on learning, researchers have discovered that teachers have little knowledge of working memory and its effect on students' progress (Science Daily Staff, 2008, p. 1). Students with working memory deficits may have a variety of characteristics in common that will help teachers determine if working memory is the problem. Alloway (2008c) believes they may be included in "low ability groups in both literacy and numeracy" (p. 1). They may struggle to remember directions, forget recent events, or have difficulty organizing tasks (p. 1). These students can also appear to have attention problems. This lack of attention may manifest itself as hyperactivity, difficulty staying seated, daydreaming during a lesson, or forgetting what to do after receiving directions.

Studies related to working memory.

Researchers have undertaken studies to examine the impact and importance of working memory dating back to Baddeley. Different views exist about working memory as an entity or as part of short-term memory. In 1980, Daneman and Carpenter studied the executive features of working memory (as cited in Baddeley, 2006, p. 21). They examined the differences among individuals' capacities to store and process information. They administered at test to university students that required them to read aloud a variety of sentences and reiterate the last word in each sentence (p. 21). They found a high correlation between reading comprehension and working memory (p. 21). If the students could recite the last word of each sentence after reading aloud, their understandings of the passage improved.

In 1989, Baddeley and Gathercole worked together to determine if the phonological loop had any impact on early language development. In this effort, they studied children ages 4 to 5 who were just beginning school. This study focused on vocabulary, the repetition of reading words with the consonant-vowel-consonant pattern

(CVC), reading nonsense words, and the relationship to the phonological-loop part of working memory. The conclusion was that students with good working memory had better vocabularies and were able to repeat CVC and nonsense words more readily.

Kane, Conway, Bleckley and Engle (2001) agree with Barkley about working memory being part of the executive-attention function. They believe that working memory is separate from short-term memory and it is about “the ability to control attention in order to maintain information in an active, quickly retrievable state” (p. 180). The executive attention “allows switching between competing tasks but maintains desired information by suppressing and inhibiting unwanted, irrelevant information” (Kane et al., 2001, p. 180). This means that the brain pays attention only to the important information. Additional studies by Pickering and Gathercole (2004), Cowan (2005), Dehn (2008) confirm Kane et al. idea of high and low memory spans. Subjects with high-memory spans are able to maintain better attention than low-memory-span subjects (Dehn, 2008, p. 27).

Susan Pickering and Susan Gathercole (2004) expanded the research on working memory by looking at students with special needs. They started with small samples of seven-year-old students who already had severe learning disabilities. Although they found some evidence to support their thinking about working memory, they explained that determining whether the nature of working memory deficits vary[ies] systematically as a function of the type of learning disability is not possible. Therefore, they decided to expand their research to a larger sample. In 2004, Gathercole and Pickering wrote about earlier research they conducted in 1999 and 2000 where they examined 734 children between the ages of four and fifteen (p. 395). All of these children were participating in the standardization of the Working Memory Test Battery for Children or WMTB-C (p. 395). From this sample, 98 students were already identified as having Special Education Needs (SEN) on varying levels, and 83 of the 98 students fell into categories outlined by the UK (p. 396). Since this study was conducted in the United Kingdom (UK), the qualification process and services provided match those outlined by the UK's Department of Education and Employment (2004). Of these 83 children, four had language deficiencies, twenty-nine had literacy problems, twenty-six had general learning problems (both math and literacy), and twenty-four had behavioral disorders, including Emotional Disturbance, Autism, attention disorders, and Asperger's syndrome (p. 395). All of the children in the study were in attendance at seven schools in southwest England and hailed from urban, suburban, and rural areas (p. 395). All of these children were tested in three sessions over a period of five to ten days (p. 395). They were tested using ten tests—nine WMTB-C tests and a visual-pattern test (p. 395).

According to Gathercole and Pickering (2004), the "profiles of working memory abilities in children with SEN varied markedly in this study as a function of the nature of their learning difficulties" (p. 403). In addition, students with language disorders and students with general learning problems (both math and literacy) had the largest deficiencies in the area of working memory (Gathercole & Pickering, 2004, p. 403). Next, students with literacy deficits had minor difficulties in working memory, and students with behavioral disorders did not have working memory problems. Pickering and Gatherole considered why students with learning difficulties have difficulty with working memory and stated that "some children have basic cognitive processing deficits that jeopardize their abilities to acquire complex skills and knowledge in areas such as literacy and mathematics and their capacities to store information" (2004, pp. 403-404). Since these children already have cognitive processing deficits, their working memory problems, although apparent, may not be what most impact their learning. Another idea from Pickering and Gatherole is that one strand of working memory may impact students more than another (2004, p. 404). For example, since phonological information may be stored in the phonological loop, students with a deficit in this area may be impacted by reading more than they are by math.

Gathercole continued her research teaming with Pickering, Knight, and Stegmann. They reported additional information on working memory and its impact on students' scores on the national curriculum assessments. This study looked at two groups of students. Group 1 consisted of forty 7 to 8 year olds who took the Key Stage 1 assessment, and group 2 consisted of forty-three 14 to 15 year olds who took the Key Stage 3 assessment (Gathercole, Pickering, Knight, & Stegmann, 2004, p. 3). All of the students took the WMTB-C, and previous studies indicated that this assessment helped identify students who would struggle in English and math.

According to Gathercole and the team, "close associations were found between children's scores on working memory measures and their national curriculum assessments" (p. 4). This study showed that working memory affected group 1 more than group 2 in the area of English. "Strong links with working memory scores were present at year 7 but not at 14, and these were both greater in magnitude and more consistent at the earlier age for the central executive than for phonological tasks" (p. 12). These researchers found that working memory is more connected to early literacy development when children are learning to read and write.

In mathematics, high association levels existed between the students' working memory scores and the results of their national math assessments. For example as explained by Gathercole et al., this study paralleled previous ones that examined working memory and mathematics and indicated that "children with poor mathematical abilities show deficits in complex working memory" (2004, p. 13). Gathercole et al. explains the association between poor working memory and subpar math skills by citing a lack of workspace in the brain to manipulate information, difficulty with long-term memory of basic facts, or a lack of control in the central executive.

Soon after this in 2005, Gathercole teamed with Alloway, Adams, Willis. Eaglen, and Lamont to examine more closely the relationship between students with special needs and their working memories. This study consisted of 64 students between the ages of seven and eleven who attended primary school the city of Durham in northeast England (p. 58). All of the students who participated in the study had educational needs and fell into three groups:

- Group 1 (School Action) — students with milder learning disabilities;
- Group 2 (School Action Plus) — students who need additional support from an external specialist; and
- Group 3 (Statements) — students requiring a written statement of special education (Alloway *et al*, 2005, p. 58)

In this study, Alloway assessed the impact of working memory by using the WMTB-C and evaluated literacy, numeracy, and language the Wechsler Objective Dimensions Test to determine academic scores (pp. 58 - 59). In addition, they employed the Wechsler Intelligence Scale for Children-3rd UK Edition to measure the students' intelligence.

The students in Group 3 had the most significant working memory impact, and the other two groups were average to below average (Alloway *et al*, 2005, p. 61). Although the students in Groups 1 and 2 were considered "higher" than those of Group 3, all of the children who participated in the study fell at least one standard deviation below the mean of 100 in the area of the phonological loop. The majority of the children in this study were significantly impacted by more than one area of working memory: "52% performed very poorly in both central executive and visuospatial tasks, and 43% of them scored below in all three areas of working memory function" (p. 64). According to these statistics, only 5% of students who had educational needs were not significantly impacted by their working memory.

Interventions to help support working memory.

Because of the research showing the impact of working memory on learning, scientists have advocated a number of interventions for improving learning. One of them, Susan Gathercole, believes that teachers need to be aware of children's developmental working memory capacities in order to create good interventions for them (as cited in Dehn, 2008, p. 232). In order to teach effectively, teachers should know what is age-appropriate for children to remember and manipulate information. Dehn (2008) stated that recent brain research shows that the "windows of opportunity for most memory processes are in early childhood and early elementary years" (p. 267). The interventions need to happen early, before the brain fully develops. According to Dehn (2008), "memory interventions, especially those of a remedial nature, need to occur before the maturing of the specific brain regions where the process of concern is located. Change is more difficult once neural structures are established and myelination is complete" (p. 267).

Working memory capacities should increase when children are ages four to fourteen. At age six, the central executive and visuospatial sketchpad are about half developed, and the phonological loop is about three-fourths developed (Dehn, 2008, p. 233). The phonological loop seems to "contribute to the development of reading skills, probably in a number of different ways" (Baddeley, 2006, p. 13). Therefore, having the foundation of phonological short-term memory development is imperative for learning language and for learning to read. (Dehn, 2008, p. 267).

In the past, teachers focused their working memory interventions on increasing the capacity of short-term memory (Dehn, 2008, p. 270). According to Dehn, teachers now center working memory interventions on moving information to long-term memory (p. 270). When making interventions with respect to memory, teachers must be aware of overloading students' working memories. Two types of "working memory-loaded" activities exist (p. 235). In the first one, children have to store substantial, random information in their short term memory at one time. In the second, they work on one activity and must store information in their short term memory that is unrelated to the activity (p. 235). According to Gathercole, "The aim is to reduce the frequency of occasions in which the child fails a learning activity and so misses a crucial learning opportunity because [of an inability] to meet the working memory demands of the situation" (as cited in Dehn, 2008, p. 235).

Gathercole et al. suggested one way to reduce the overloading of students' brains is to shorten the amount of instruction given at one time and to employ child-friendly language (Gatherole, et al, 2006, p. 235). In addition, Dehn claims that using simple repetition (rote strategies) is important for giving children opportunities to repeat numerous times what they have done in order to learn it well (Dehn, 2008, p. 271). This will reduce the number of demands on the students' working memories, and skills will become automatic (Dehn, 2008, p. 271). Also, adding continual practice and review helps students develop working memory. Students need direct instruction on a skill followed by short intervals of practice and review. These short intervals help students retain information for long periods of time (Dehn, 2008, p. 287).

Gathercole et al. also suggested that when asking a child to remember information over an extended period, the teacher should focus on the "crucial information rather than repetition of original instruction" (p. 236). They believe repetition of the material learned will help the child remember and utilize the information later. If later the child is unable to remember the material, the teacher must require that the child attempt to remember it before providing the information. These attempts help improve the child's working memory performance and retrieval results in the future (p. 236).

In addition to rote strategies, relational strategies also help students remember information. Relational strategies are higher-level thinking strategies that help make the information more meaningful (Dehn, 2008, p. 272). Under these strategies, students are taught about their schema or background knowledge. When students are aware of their background knowledge, they need to be taught to use it to make connections to new information. Once they can connect old information to new information, they are more likely to remember the new information. Relational strategies make the information more meaningful so it influences new learning through these connections (Dehn, 2008, p. 272).

One of the simplest strategies for transferring information from working memory to long-term memory is the use of rehearsal strategies. Under these strategies, the student repeats the information orally as if rehearsing a part in a play. This repetitive processes "allows information to be maintained in working memory for a longer period of time" (as cited in Dehn, 2008, p. 272). Many studies, such as those by Comblain (1994), Conners et al (2001), Klingberg et al (2002), Olesen et al (2003, Minear and Shah (2006), and Hulme and Mackenzie (1992), show that working memory can be improved through the implementation of explicit rehearsal strategies (as cited in Dehn, 2008, p. 273).

Another strategy for improving working memory is chunking information. The term "chunking" suggests that information is divided or grouped so students can process and remember it more easily (Dehn, 2008, p. 275). For instance, remembering a list of 14 numbers (i.e. 14929111912206) in order after looking at them for five seconds is difficult. The same numbers, after they have been chunked (i.e. 1492-911-1912-206), are easier to remember.

The chunked numbers are easier to remember for two reasons. First, humans are better at remembering numeric dates, phone numbers, social security numbers, etc., because the numbers are segments. Second, when meaning is added to the chunk, the information is even easier to remember (i.e., 1492-the year of Christopher Columbus sailed the Atlantic Ocean; 911 – the emergency telephone number; 1912 – the year the Titanic sunk; 206 – the number of bones in the human body). Chunking can be used to develop reading as well as mathematics. Students are taught to decode words with which they are unfamiliar by chunking them into words they know.

Paraphrasing is another strategy for improving working memory. When a teacher asks a student to orally paraphrase text or information learned, the teacher is employing multiple working memory strategies. The student first chunks the information into meaningful parts and then orally repeats the chunks in order to remember the entire chain of information. One difficult part about teaching paraphrasing is that students use their own words to make sense of the information. Paraphrasing can be useful for remembering directions, aiding in reading comprehension, and picking out meaningful parts of a mathematics story problem.

Memory aids are important, but typically, children with working memory deficits do not use external-memory aids (Gathercole et al, p. 236). Rather, they tend to resort to more simple memory strategies (Gathercole et al, p. 236). Gathercole and team recommend that teachers have students repeatedly practice using memory aids so that the process becomes more automatic (2006, p. 236). One strategy used is a mnemonic memory aid. Mnemonics is a "subtype of memory strategies that enhance[s] the meaningfulness of the material to be remembered, thereby facilitating learning" (p. 280). Upon the implementation of a mnemonic strategy developed by Scruggs and Mastropieri, students who were diagnosed with learning disabilities were able to correctly recall 79% of mnemonically taught content while only 27.9% were able to correctly recall material presented non-mnemonically (as cited in Dehn, 2008, p. 304). This shows that students with learning disabilities who have working memory problems need something like mnemonics to help their brains link to concepts. Once the students understand the concept, they are more likely to remember the learned material, if they employ the strategy. Gathercole et al. also advocate the use of written external-memory aids. During writing activities, supplying the children with the spellings of key words so their memories focus on the content is helpful. They also pointed out that visual aids should be placed near the students' writing papers to reduce the length of memory transfer (p.236). For example, words written on a bulletin board across the classroom are not so valuable to children with working memory deficits as lists on their desks. The proximity of the lists helps them not to lose their places so easily.

Additionally, direct interventions can help students remember everyday routines and tasks that will aid in improving their executive skills related to working memory. Some students may need the use of a daily chart so they know what will happen next in their day. Other students need a list of what steps to take to complete a task (Dawson & Guare, 2009, p. 103). Still other children with working memory deficits need positive reinforcement or built-in incentives to help them complete the tasks (Dawson & Guare, 2009, p. 77). This positive reinforcement may be the connection the child needs to complete the task successfully the next day. Once the child is able to complete the task with a certain level of support, the adult must decrease the level of support in order to encourage the child's independence (p. 77). Through repetition and continually decreasing support, the child will be able to complete the task with minimal assistance or entirely independently.

Computerized working memory programs are also available to support students with working memory deficits. Alloway (2010) created *Jungle Memory*, a program designed to improve the working memory spans of students with dyslexia. Clinical trials completed using *Jungle Memory* have shown significant progress in IQ, working memory, and academics in as little as four weeks.

Another computer program, based on research by Klingberg, Fernell, Olessen, Johnston, Gustafsson, Dahstrom, et al. (2005), Martinussen and Tannock (2006), and Olesen, Westerberg, and Klingberg (2004) and trademarked by *RoboMemo* (2006), is intended to improve working memory spans and attention spans of children with Attention Deficit Hyper-Activity Disorder. This program, called *Cogmed*, increases working memory capacity and improves cognitive performance ("Cogmed Solutions", 2011).

Computer-based working memory intervention has positive and negative characteristics. On one hand, it allows students to work at their convenience and at home and increases or decreases their ability levels based on their working-memory performances (Dehn (2008) p. 297). On the other, the programs' lack of meta-cognition or strategy learning may make it difficult for students to maintain the skills they have acquired (p. 297).

Working memory interventions are used to train individuals' brains to manipulate and use information more easily. These interventions can be helpful when used often. Although the interventions are used with students with working memory deficits, all students can benefit from employing them (Dehn, 2008, p. 305).

Summary

This review of the literature served as an overview of the study of intelligence and intelligence testing. Also included were the history of special education, some comments on special education law, an overview of Response to Intervention, an explanation of the qualification process for students with learning disabilities, and a discussion regarding working memory and its impact on learning. A brief examination of interventions appeared toward the end of the chapter. Next, in chapter three, the researcher discusses the study's research design, population, sample, and sampling procedures, including the instrumentation and measurement tools. In addition, an articulation of the study's validity, reliability, and data collection procedures is provided, as well as a description of the study's data analysis, hypothesis tests, and limitations.

Chapter Three

Methods

This study had four purposes. The first was to determine the impact of working memory on special education eligibility and to investigate whether working memory significantly impacts the academic achievement of students who are referred for a special education evaluation. The second was to learn whether differences in working memory deficits exist among students who do not qualify for special education services, and the third was to determine whether working memory deficits exist in those who qualified for special education under the category of specific learning disabilities. The last purpose was to establish whether working memory deficits of children, who qualify for Specific Learning Disabilities, were influenced by gender.

Included in this chapter are descriptions of the research design, the population, the sample, and sampling procedures; an explanation of the measurement tools; an articulation of the validity, reliability, and data collection procedures, and lastly, a description of the data analysis, hypothesis tests, and limitations of the study.

Research Design

This study was of quantitative, quasi-experimental research design, which “does not provide for full control of potential confounding variables primarily because it does not randomly assign participants to comparison groups” (Johnson & Christiansen, 2008, p. 598). Quantitative research “relies primarily on the collection of numeric data” (Johnson & Christiansen, 2008, p. 33). In this study, the researcher analyzed the differences among index scores to determine the impact of working memory on ABC School District students who were referred for eligibility for special education programs. The researcher also examined the scores of students who did not qualify for any disability and those who qualified for having Specific Learning Disabilities based upon Missouri eligibility criteria. All significance was calculated using the WISC-IV index category scores. Four index scores were computed and compared to determine the full-scale intelligence quotient: *Verbal Comprehension*, *Perceptual Reasoning*, *Working Memory*, and *Processing Speed.*

Population and Sample

The population of the study included all students attending the ABC School District during 2009-2010 school year who were evaluated for special education programs. These students came from a variety of ethnic backgrounds and social classes as described in chapter one. The study sample included 188 students, all of whom were referred for special education services using the WISC-IV. Three different subgroup categories make up the sample of students. The first group consisted of the entire sample of students referred for special education services who took the WISC-IV; the second group had students who did not qualify for a disability; the last group qualified for Specific Learning Disabilities under Missouri criteria when assessed by the WISC-IV.

Sampling Procedures

The researcher used purposive sampling to determine the sample. Purposive sampling involves “selecting a sample based on the researcher’s experience or knowledge of the group being sampled” (Lunenburg & Irby, 2008, p. 175). The researcher utilized it because of her interest in the effects of working memory on students who were tested to receive special education services, who did not qualify for special education services, and who qualified for learning disabilities.

The characteristics of the students chosen for the study had to fall within clear criteria. All of them were referred for special education during the 2009-2010 school year because of RtI or other factors. All of them attended one of the 19 schools in the ABC school district, and all of them ranged in age six to sixteen. Of the 335 students evaluated for special education placement, the sample included 188 students who were assessed using the WISC-IV to determine their intelligence quotients and their IQ index scores.

Instrumentation

Wechsler reported (2003) that the WISC-IV "is an individually administered, clinical instrument for assessing the cognitive abilities of children from age 6 through 16 and 11 months" (p. 1). Examiners employ up to fifteen subtests to determine children's full-scale intelligence quotients or IQ (Wechsler, 2003, p. 2). The full-scale IQ is intended to "represent the child's overall cognitive ability" and is based on a mean of 100 and standard deviation of 15 (Wechsler, 2003, p. 2).

In addition to determining the full-scale IQ, the WISC-IV also provides the test examiner with four index scores: *Verbal Comprehension*, *Perceptual Reasoning*, *Working Memory*, and *Processing Speed*. Each index score is based on a mean of 100 and standard deviation of 15 (ABC Evaluation Report, 2010a, p. 1). The 15 subtests fall those four index score categories. Table 3 below displays the 15 subtests. According to Wechsler (2003), ten of the subtests are core tests and are utilized when the composite score for the index score categories are needed (p. 27). These ten subtests appear in boldface in Table 3. The other five subtests can substitute for the core subtests (Wechsler, 2003, p.27) and are in plain type in Table 3. Wechsler (2003) explained the rules for substituting subtests and described the relationship between the index scores and the subtests in the WISC-IV Examiner's Manual (p. 27). These subtests were used with some students in this study. The test examiners followed the WISC-IV manual when deciding whether to use these subtests.

Table 3

WISC-IV Index Scores with Subtests

Verbal Comprehension	Perceptual Reasoning	Working Memory	Processing Speed
Similarities	**Block Design**	**Digit Span**	**Coding**
Vocabulary	**Picture Concepts**	**Letter-Number Sequencing**	**Symbol Search**
Comprehension	**Matrix Reasoning**	Arithmetic	Cancellation
Information	Picture Completion		
Word Reasoning			

Note. Core Subtests are in boldface. From "WISC-IV Administration and Scoring Manual," by David Wechsler, 2003.

According to Wechsler, verbal comprehension could be "termed a test of common sense," as the Army Alpha version referred to it (1944, p. 181). The *Verbal Comprehension* index score measures students' abilities to answer questions about practical information and to evaluate past experiences in order to generalize what may happen in a similar circumstance (Wechsler, 1944, p. 181). The *Verbal Comprehension* index score is determined by administering the following core subtests: Similarities, Vocabulary, and Comprehension. For further information, the test examiner can administer Information and Word Reasoning subtests. For the Similarities subtest, the examiner provides two words that have something in common, and the child must determine in what way the words are the same (Wechsler, 2003). During the Vocabulary subtest, the examiner holds up a picture, and the child must name the object, or the examiner states a word, and the child must give the word's definition (Wechsler, 2003). For the Comprehension subtest, the child answers questions using general knowledge and social judgment (Wechsler, 2003). During the Information subtest, the child answers additional general information questions (Wechsler, 2003). For the Word Reasoning subtest, the examiner gives the child a list of clues, and the child must identify common concepts (Wechsler, 2003).

Perceptual reasoning is the ability to reason "with visual stimuli and also includes elements of spatial processing and visual-motor integration" (Weiss, Saklofske, Prifitera, & Holdnack, 2006, p. 78). The following subtests are designed to determine the *Perceptual Reasoning* index score: Block Design, Picture Concepts, Matrix Reasoning, and Picture Completion. For Block Design, the examiner displays a picture and gives the child some red and white colored blocks. In a set amount of time, the child must look at the model and construct the design using the blocks (Wechsler, 2003). For Picture Concepts, the tester shows the child a series of pictures, and the child must determine which ones go together and why (Wechsler, 2003). During the Matrix Reasoning subtest, the child is shown a matrix with one missing part and must determine what is missing based on a list of choices (Wechsler, 2003). For the Picture Completion subtest, the child must, within a time limit, determine what is missing from a picture (Wechsler, 2003).

Working memory is the "ability to temporarily retain information in memory, perform some operation or manipulation with it, and produce a result" (Weiss *et al*, 2006, p.78). Three subtests fall under the *Working Memory* index category: Digit Span, Letter-Number Sequencing, and Arithmetic. For the Digit Span subtest, the child receives numbers and, during one part of the test, must repeat them just as the examiner says them—in a forward pattern. During another part, the child must repeat the numbers backwards (Wechsler, 2003). For the Letter-Number Sequencing subtest, the child is given a list of numbers and letters in random order. The child must repeat the numbers in order from lowest to highest and the letters in alphabetical order (e.g. The correct answer for 9, K, 2, I, 8, F would be 2, 8, 9, F, I, K). For the Arithmetic subtest, the child must solve mentally and within a time limit a series of math problems (Wechsler, 2003).

Processing speed is the "ability to scan, sequence, or discriminate simple visual information quickly and correctly" (Weiss *et al*, 2006, p. 79). Three subtests come under the *Processing Speed* index category: Coding, Symbol Search, and Cancellation. All of these tests are timed in order to determine how quickly the child can complete the task. During the Coding subtest, the child receives a key with numbers and symbols and must draw the correct symbol in the appropriate numbered box within a given time. For the Symbol Search subtest, the child scans a line of symbols to determine which one matches a target symbol (Wechsler, 2003). During the Cancellation test, the child receives a random and a structured arrangement of pictures and must mark a target picture as many times as possible within a given amount of time (Wechsler, 2003).

In the ABC School District, two school psychological examiners administer the WISC-IV. In the WISC-IV testing manual, Wechsler emphasized that the test examiners must have proper training and be familiar with all parts of the assessment (2003, p. 19). Both of the psychological examiners in the ABC School District have been trained to give the WISC-IV. They received certification through the Missouri Department of Elementary and Secondary Education in 2003 and attained their positions the following year through the ABC School District, where they have administered the WISC-IV (Test Examiner C, personal communication, February 2011).

For the majority of children, the ten core subtests take 65 to 80 minutes (Wechsler, 2003, p. 21). Ideally, the examiner should administer the test in a single session, but two sessions is permissible if the child becomes tired (Wechsler, 2003, p. 21). In the event that the testing session is split into two, the second one should take place within a week of the first one in order to keep the scores reliable and valid (Wechsler, 2003, p. 21).

Additionally, Wechsler provided specific guidelines for the order in which the examiners should administer the subtests to the students. The examiner must use specific verbiage, follow the testing manual, and apply detailed starting-point and discontinue rules for each test. Since each subtest is administered and scored differently, the examiner must use the manual to know how to give the test (Wechsler, 2003).

The subtests are scored by using raw scores, which are "the number of points a student receive[s] for correctly answering questions on a test" (Pearson, 2008, p.1). After calculating the raw score, the examiner "converts the raw scores to scaled scores" as outlined in the testing manual (Wechsler, 2003, p. 47). Scaled scores are calculated using the student's age in years and months (Wechsler, 2003, p. 47). Next, the examiner sums the subtest scores and then uses the result and a conversion chart in the examiner's manual to determine the student's composite scores for *Verbal Comprehension, Perceptual Reasoning, Working Memory*, and *Processing Speed* along with the full-scale

IQ score. In addition, the examiner determines percentile rankings and confidence intervals by using the conversion table (Wechsler 2003, p. 49).

The WISC-IV was administered to all students in quiet, one-on-one settings (Test Examiner G, personal communication, December, 2010). This provided each student with an environment free from the distractions of a general education classroom. The test was administered by an authorized examiner according to the General Testing, Administration, and Scoring Guidelines set forth in the WISC-IV Testing Administration and Scoring Manual (Wechsler, 2003, p. 19). All of the proper testing materials, which are included in the WISC-IV test kit, were utilized as designed by Wechsler.

In addition to the WISC score, examiners use academic tests to determine whether the presence of a disability qualifies a student for special education. First, the examiner gives the student an academic assessment in an area in which the student is struggling. These academic assessments can be in reading, writing, mathematics, or a combination of all three. All of these academic tests are scaled the same as the IQ assessment, with a mean of 100 and a standard deviation of 15. The academic and IQ scores are therefore comparable. Once the academic tests are administered and scored, the examiner compares the WISC IV IQ score to academic-achievement-test results. If the student has academic scores in reading, writing, or math that are 23 points below the IQ score and shows lack of achievement in the general education classroom, the student qualifies as having a learning disability in one or more of the following areas: basic reading, reading fluency, reading comprehension, written expression, math problem solving, and/or math calculation.

Validity and Reliability

The WISC-IV is a norm-referenced test based on a sample of "2,200 children from 11 age groups (each one-year wide), with an equal number of males and females in each group, and an ethnic breakdown that matches the March 2000 U.S. Census data very closely" (Niolon, 2005, p. 2). The children in the sample group were from all over the United States, including Alaska and Hawaii, and came from homes with varying levels of parental education (Niolon, 2005, p. 3). These norms were used to develop a conversion chart to determine the children's IQ scores.

According to Johnson and Christensen, validity and reliability are the "two most important psychometric properties to consider when using a test" (2008, p. 143). Validity measures "the accuracy of the inferences or interpretations you make from the test scores" (Johnson and Christensen, 2008, p. 144). When Wechsler began writing his assessments, he did not have specific numbers confirming the validity of the IQ test. After creating the Wechsler Adult Intelligence Scale in the 1940's, he wrote:

> The only honest reply we can make is that our own experience has shown them to be so. If this seems to be a very tenuous answer we need only remind the reader that it has been practical experience which has given " or denied" final validity to every other intelligence test. All evidence of the validity of the test whether statistical or otherwise is inevitably of an indirect sort and in the end cumulative rather than decisive. (Wechsler, 1944, pp. 127-128)

The WISC-IV was assessed using two types of validity: criterion validity and construct validity. Criterion validity measures evidence suggesting that similar scores will occur in the future (Johnson & Christiansen, 2008, p. 584). According to Sattler and Dumont, “studies of the validity of the WISC-III indicate that it had adequate construct, concurrent, and predictive validity for many types of children with or without disabilities in the age range covered by the test” (2004 p. 12). The sample for Sattler and Dumont’s (2004) validation study was comprised of 244 children between the ages of 6 and 16. All of these children were given the WISC-III and the WISC-IV within a 5 to 67 day period (p. 12). The correlations appear in Table 4 below. The *Verbal Comprehension* index and the *Perceptual Reasoning* index have two scores each, because on the WISC-III, Wechsler had more than one index score for *Verbal Comprehension* and more than one score for *Perceptual Reasoning*. The WISC-III index scores were validated previously. Therefore, the WISC-III scores correlate with the WISC-IV and allow for generalization between the scores. All correlations of WISC-III and WISC-IV scores were above 0.7 which provides substantial evidence of good validity (George & Mallery, 2003, p. 231).

Table 4

WISC-III and WISC-IV Validity Correlations

		WISC IV				
		VCI	PRI	WMI	PSI	FSIQ
	VIQ	.83				
	VCI	.85				
WISC III	PIQ		.73			
	POI		.70			
	FDI			.74		
	PSI				.81	
	FSIQ					.87

From "Assessment of Children WISC-IV and WPPSI Supplement," byJerome Sattler and Ron Dumont, 2004. Note: VCI = Verbal Comprehension Index, PRI = Perceptual Reasoning Index, WMI = Working Memory Index, PSI = Processing Speed Index, FSIQ = Full Scale IQ, VIQ = Verbal IQ, PIQ =Perceptual IQ, POI = Perceptual Organization Index, and FDI = Freedom of Distractibility Index.

Construct validity is the extent to which an abstract construct is measured by any measurement (Johnson & Christianson, 2008, p. 584). According to Sattler and Dumont (2004) the "inter-correlations [among] 15 subtests range from a low of .10 to a high of .75" (p. 15). The correlations in Table 4 are greater than 0.7, which is considered good evidence of validity (George & Mallery, 2003, p. 231). The *Verbal Comprehension* subtest correlates more highly than do the *Perceptual Reasoning*, *Working Memory,* and *Processing Speed* subtests (Sattler and Dumont, 2004, p. 16). In addition, the "average correlations range from .70 to .91 (Median r = .86*)* between the *Verbal Comprehension* subtests and the *Verbal Comprehension* composite, from .57 to .84 (Median r = .79*)* between the *Perceptual Reasoning* composite, from .57 to .86 (Median r = .86*)* (Median r = .86*)* between the *Working Memory* subtests and the *Working Memory* composite, and from .41 to .88 (Median r = .87*)* between the *Processing Speed* subtests and the *Processing Speed* composite" (Sattler, 2001, p. 16).

Wechsler described the reliability of the WISC-IV as the "consistency with which it measures the abilities it sets out to test" (Wechsler, 1944, p. 133). According to Sattler and Dumont, the WISC-IV has good reliability (2004, p. 7). The reliability of the measurement of IQ was based on a sample of 11 groups of children of varying ages. The full-scale range of coefficients based on this sample was .96 to .97, with a mean coefficient of .97. All of these reliability coefficients provide evidence of strong reliability (George & Mallery, 2003). Additional reliability coefficients by index score are listed below in Table 5.

Table 5

WISC-IV Internal Consistency Reliability Coefficients

Index Scores	Range of Coefficients	Mean Coefficient
Verbal Comprehension	.91 to .95	.94
Perceptual Reasoning	.91 to .93	.92
Working Memory	.90 to .93	.92
Processing Speed	.81 to .90	.88

From "Assessment of Children WISC-IV and WPPSI Supplement," by Jerome Sattler and Ron Dumont, 2004.

Test-retest reliability was also assessed. Test-retest reliability is when the researcher gives the same test to an individual after a period of time to determine if the scores are consistent (Johnson & Christiansen, 2008, p. 603). Wechsler provided statistics on reliability correlations between tests as .94 for children 10 to 13 on the WAIS (1944, p. 133). The WISC-IV was also assessed for test-retest reliability "by retesting after an interval of 13 to 63 days (*M* =32 days), 18 to 27 children from each of the 11 age groups [were] in the standardized sample), yielding a total of 243 children" (as cited in Sattler and Dumont, 2004, p. 7).

Data Collection Procedures

Prior to collecting the data for this clinical-research study, the researcher requested the consent of the ABC School District through the submission of a proposal, and the Deputy Superintendent of Curriculum and Instruction and the Assistant Superintendent of Special Services for the ABC School District approved it (See Appendix A). In addition, the researcher applied to the Baker University Institutional Review Board for permission to conduct the study (See Appendix B). After obtaining the ABC School District's approval, the researcher received the archived data from the testing examiners in an Excel worksheet and the WISC-IV score pages for each student. On the worksheet, identification numbers replaced the names of the students in order to keep IQ information anonymous and confidential. Next to each student's identification number was the IQ test result for that child during the 2009-2010 school year. If the student took the WISC-IV, then the researcher received index scores, full scale scores, and gender identification as well. If students' general-ability index scores were calculated as a part of their evaluations, those were also included on the spreadsheet. In addition, specific special education categories were listed to show the area of qualification. The worksheet also included the initials of the test examiners to indicate which examiner tested each child.

Data Analysis and Hypothesis Tests

Hypotheses were developed in order to address each of the research questions. The researcher imported the data into Statistical Package for the Social Sciences SPSS

PASW 18.0. The IQ index score means were computed among students who were tested for disabilities, students who did not qualify as having disabilities according to Missouri criteria, and students who qualified as having learning disabilities under the same criteria. Each research question is listed below followed by the hypothesis and the analysis used.

Research question one: For students who are referred for special education, to what extent is working memory a major deficit area?

Research hypothesis one: Students who are referred for special education testing are considered to have a major deficit in working memory.

For research question number one, the researcher utilized a one-factor-repeated-measures analysis of variance (ANOVA). The means of the four index scores were compared to determine if there were statistically significant differences in the index scores (α = .05). A Tukey post-hoc was conducted to determine further significance. This helped the researcher determine if students who are referred for special education have significant working memory deficits in comparison to the other index scores.

Research question two: For students who do not qualify under Missouri criteria for any special education diagnosis, to what extent is working memory a major deficit area?

Research hypothesis two: Working memory is the major deficit area for students who do not qualify as having disabilities according to Missouri eligibility criteria.

For research question number two, the researcher utilized a one-factor-repeated-measures ANOVA. The means of the four index scores were compared to determine if there were statistically significant differences in the index scores (α = .05). For this question, a Tukey post-hoc was not used due to lack of significance. This helped the researcher determine if students who do not qualify for Specific Learning Disabilities according to Missouri criteria have significant working memory deficits in comparison to the other index scores.

Research question three: For students who qualify for a Specific Learning Disability under Missouri criteria, to what extent is working memory a significant factor in the diagnosis of a learning disability?

Research hypothesis three: Working memory is the most significant deficit area for students who qualify as having learning disabilities.

For question number three, the researcher utilized a one-factor-repeated-measures ANOVA. The means of the four index scores were compared to determine if there were statistically significant differences in the index scores ($\alpha = .05$). A Tukey post-hoc was utilized to determine further significance. This helped the researcher determine if students who qualify as having specific learning disabilities according to Missouri criteria have significant working memory deficits in comparison to the other index scores.

Research question four: Of the students, who qualify for Specific Learning Disabilities under Missouri criteria, to what extent are *Working Memory* index scores affected by gender?

Research hypothesis four: The extent to which working memory is a major deficit area affects boys more than girls.

For research question four, the researcher utilized a two-factor one-between/one-repeated-measures ANOVA. The means of the four index scores were compared to male and female to determine if there were statistically significant differences. This helped the researcher determine if gender affected the differences among the index scores.

Limitations

This study potentially had the following limitations.

1. Some ABC District students were given other intelligence tests and were not included in the sample. These students took the Stanford Binet, the Wechsler Adult Intelligence Scale-IV, the Bayley, or the Wechsler Preschool Primary Scale of Intelligence. A smaller sample size could have affected the results of the analysis.
2. Since the WISC-IV is designed for students from ages six through 16, students under six years old or over 16 were not included in the sample and were given different IQ tests. Therefore, one can only generalize to students between the ages of 6 and 16. The smaller sample size could limit to some extent the results of the analysis.
3. The students who were given the WISC-IV were tested by two different examiners. This could potentially limit the study, if discrepancies were found.

Summary

Chapter three provided an overview of the quasi-experimental, quantitative research study. The research questions and hypotheses were outlined in this chapter. The population and sample were described as well as the sampling procedures. In addition, the WISC-IV was explained in more detail. In Chapter four, the results of the hypothesis testing are uncovered to determine the extent to which working memory impacts students who are referred for special education evaluation.

Chapter Four

Results

As stated previously, three groups of students' scores were analyzed for this study. The researcher examined the index scores of three groups of students to determine differences in working memory scores among students who were tested for admission to special education programs, students who did not qualify for services, and students who qualified as having learning disabilities. The researcher analyzed scores to determine if working memory was the principal deficit area. The researcher also determined the extent to which working memory deficits affect boys more than girls. In this chapter, the researcher describes the data related to the study. Each hypothesis was tested using Analysis of Variance.

Descriptive Statistics

The study's population consisted of 335 students who were tested for qualification for special education services in the ABC School District. The sample used was 188 students who were tested to determine special education qualification and were given the WISC-IV to determine their full-scale IQ score as well as index scores. All of the data were placed into the SPSS PASW 18.0 to calculate frequencies for variables such as gender, school, etc., in order to address the four research questions. Students ranged in age from 6 to 16. Of these 188 students, 70 were female, and 118 were male. The students attended one of the 19 different schools in the ABC School District. In addition, all students except one were tested by one of two test examiners or both as shown in Table 6. There were 74 students tested by Examiner C, 112 students tested by Examiner G, 1 student tested by Examiner P, and 1 student tested by Examiner C and G.

Examiner S is a school counselor in the ABC School District and tested one student in her building due to an evaluation team decision (Examiner G, personal communication, October 2011).

Table 6

Frequency of Students tested with each Examiner

Examiner	Frequency of Students
Examiner C	74
Examiner G	112
Examiner P	1
Examiner C & G	1

In order for special education testing to occur, either parents or school personnel must refer the students for assessment. Table 7 displays information on the types of referrals that were made for all of the students tested. School personnel referred the largest proportion (68%) of students for special education testing.

Table 7

Frequency of Referrals for Special Education Testing

Type of Referral	Frequency of Students
Parent	59
School	127
Parent and School	2

In addition, there are 13 categorical disability diagnoses for which a student can qualify for special education services exist under Missouri criteria. Table 8 summarizes the nine categorical disabilities for which students qualified during the 2009-2010 school year. Over 50% of the diagnoses were Specific Learning Disabilities (104 out of 188 students). The other 84 students were diagnosed with a variety of disabilities: Autism, Articulation, Other Health Impaired, Language, Mental Retardation, and Emotional Disturbance. Only one student qualified under the category Traumatic Brain Injury, and another qualified with a Hearing Impairment.

Table 8

Frequency of Students Qualifying for Disabilities

Type of Disability	Frequency of Students	Percentage of Students
Articulation	3	1.6
Autism	5	2.7
Emotional Disturbance	20	10.6
Hearing Impairment	1	.5
Language	5	2.7
Specific Learning Disability	104	55.3
Mental Retardation	12	6.4
Other Health Impaired	10	5.3
Traumatic Brain Injury	1	.5
Did not qualify for any disability	27	14.4

The descriptive statistics described above provided detailed information about the study sample. The researcher next describes the results of hypothesis testing for research questions one through four.

Hypothesis Testing

Hypothesis testing was conducted to determine if students referred for special education testing, students who did not qualify for special education services, and students who qualified as having learning disabilities had significant deficits in *Working Memory* in comparison to the other IQ index scores: *Verbal Comprehension, Perceptual Reasoning*, and *Processing Speed*. Additional hypothesis testing was conducted to determine if differences among the four index scores were linked to gender.

Research question one: For students who are referred for special education, to what extent is working memory a major deficit area?

Research hypothesis one: Students who are referred for special education testing have major working memory deficits.

A repeated measures (or within subjects) one factor ANOVA was used to test research hypothesis one. A post-hoc analysis was conducted because the F-test indicated a statistically significant difference between at least two of the means (F = 19.55, df = 3, 561, p = .000). The post- hoc analysis allowed the researcher to determine which means were different. The researcher utilized the Tukey HSD, with a significance level of .05. To be significantly different, the means had to be 2.803 IQ units apart. *Working Memory* index scores (92.46) were statistically lower than those of *Verbal Comprehension* (96.38) and *Perceptual Reasoning* (96.95). *Processing Speed* scores (89.72) were statistically lower than those of *Verbal Comprehension* (96.38) and *Perceptual Reasoning* (96.95). *Verbal Comprehension* and *Perceptual Reasoning* scores were not different, as were the scores for *Working Memory* and *Processing Speed*. Table 9 includes the index categories, means, standard deviations, and numbers of students assessed.

Table 9

Index Score Descriptive Statistics for Hypothesis Test 1

Index Category	Mean	Standard Deviation	Number of Students
Verbal Comprehension	96.3830	13.36017	188
Perceptual Reasoning	96.9468	16.21240	188
Working Memory	92.4574	15.30312	188
Processing Speed	89.7234	15.40186	188

Research question two: For students who do not qualify under Missouri criteria for any special education diagnosis, to what extent is working memory a major deficit area?

Research hypothesis two: Working memory is the major deficit area for students who do not qualify as having disabilities according to Missouri eligibility criteria.

A repeated measures (or within subjects) one factor ANOVA was used to test research hypothesis two. The dependent variables for the test were the index scores: *Verbal Comprehension*, *Perceptual Reasoning*, *Working Memory*, and *Processing Speed*. The scores were examined for students who did not qualify for special education programs. The sample consisted of 27 students. The results of this analysis did not provide evidence of statistically significant differences among the index score means (F = .713, df = 3, 78, p = .547). *Verbal Comprehension* and *Perceptual Reasoning* index scores were the most discrepant, with a difference of a little less than three points. *Verbal Comprehension* and *Working Memory* index scores were within one point of each other, and so were the index scores for *Working Memory* and *Processing Speed*. These differences were not statistically significant. Table 10 presents the descriptive statistics for Hypothesis Test 2.

Table 10

Index Score Descriptive Statistics for Hypothesis Test 2

Index Category	Mean	Standard Deviation	Number of Students
Verbal Comprehension	92.6667	10.96849	27
Perceptual Reasoning	89.7037	13.29492	27
Working Memory	91.5926	10.30780	27
Processing Speed	90.0741	11.76019	27

Research question three: For students who qualify for a Specific Learning Disability under Missouri criteria, to what extent is working memory a significant factor in the diagnosis of a learning disability?

Research hypothesis three: Working memory is the most significant deficit area for students who qualify as having learning disabilities.

A repeated measures (or within subjects) one factor ANOVA was used to answer research questions and test hypothesis three. A post-hoc analysis was conducted because the F-test indicated a statistical difference between at least two of the means (F = 10.538, df = 3, 309, p = .000). A post-hoc analysis allows the researcher to determine which means were different. The researcher utilized the Tukey HSD, with a significance level of .000. To be significantly different, the means had to be 4.0995 IQ units apart. The result of the post-hoc analysis provides partial support for hypothesis three. *Working*

Memory (97.04) was statistically lower than *Perceptual Reasoning* (101.75). *Processing Speed* (93.3846) was statistically lower than *Verbal Comprehension* (100.01) and *Perceptual Reasoning* (101.75). The scores for *Verbal Comprehension* and *Perceptual Reasoning* were the not different. *Working Memory* scores were lower than those of *Perceptual Reasoning* but not significantly lower than *Verbal Comprehension*. *Processing Speed* appeared to impact students with learning disabilities more than *Working Memory*. Table 11 includes the index category, mean, standard deviation, and number of students who were assessed for Hypothesis Test 3.

Table 11

Index Score Descriptive Statistics for Hypothesis Test 3

Index Category	Mean	Standard Deviation	Number of Students
Verbal Comprehension	100.0096	11.53761	104
Perceptual Reasoning	101.7500	14.04345	104
Working Memory	97.0385	14.37158	104
Processing Speed	93.3846	15.46955	104

Research question four: Of the students, who qualify for Specific Learning Disabilities under Missouri criteria, to what extent are *Working Memory* index scores affected by gender?

Research hypothesis four: The extent to which working memory is a major deficit area affects boys more than girls.

A two factor (one between and one within) ANOVA was used for Hypothesis Test 4. The researcher used the sample of students who qualified as having learning disabilities: 39 were female and 65 were male. The assessment included three parts: one test was a main effect for index category, the second was a main effect for gender, and the third was an interaction effect for gender by category. The first two parts did not address research question four. The results of the test for an interaction indicated a marginally significant effect (F = 2.414, df = 3, 306, p = .067). Table 12 presents the means, standard deviations, and numbers of Females and Males who took the WISC-IV.

Table 12

Index Score Descriptive Statistics for Males and Females in Hypothesis Test 4

Index Category	Gender	Mean	Standard Deviation	Number of Students
Verbal Comprehension	Female	100.8974	12.26419	39
	Male	99.4769	11.14269	65
Perceptual Reasoning	Female	98.8718	14.44259	39
	Male	103.4769	13.61881	65
Working Memory	Female	96.6154	10.04887	39
	Male	97.2923	16.50068	65
Processing Speed	Female	95.8205	14.86053	39
	Male	91.9231	15.75526	65

In addition, Figure 1 (below) provides a visual display of the means. Upon examining Figure 1, the researcher concluded that males and females have somewhat different strengths and weaknesses on the IQ test. According to the data in Figure 1, female *Verbal Comprehension* scores are slightly higher than those of males, and female

Perceptual Reasoning scores are lower than those of males. *Working Memory* scores for males and females are fairly commensurate, while *Processing Speed* is lower for males than females. However, these observed differences were not statistically significant.

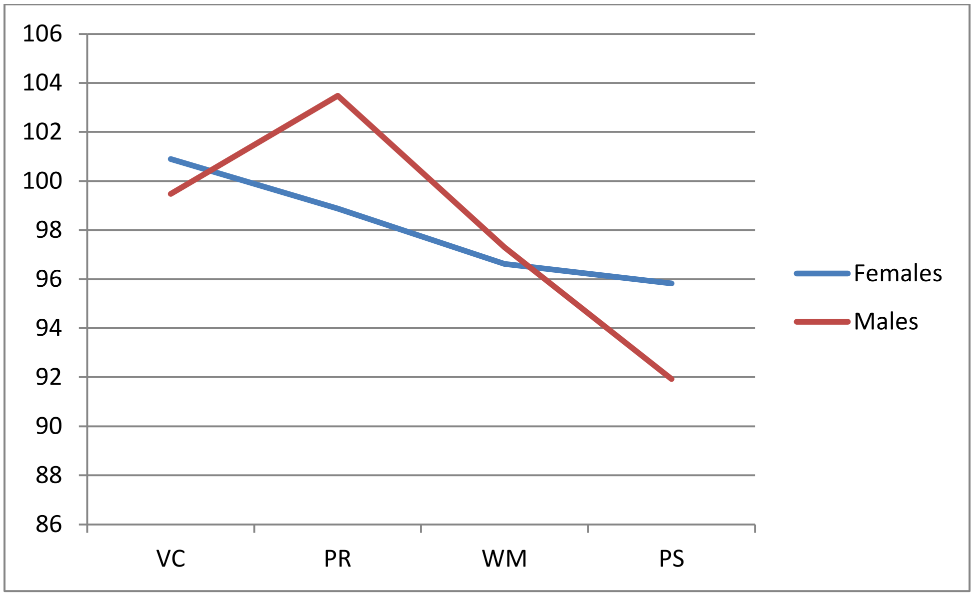

Figure 3. Mean index scores by gender.

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, WM = Working Memory, and PS = Processing Speed. Index scores are distributed with a mean of 100 and a standard deviation of 15.

Additional Analyses

Additional analyses were conducted to determine if the results from the hypothesis testing were influenced by the test examiners who administered the WISC-IV.

A two factor (one between and one within) ANOVA was used to determine whether the test examiners' influence caused a significant difference in index scores for the entire sample. The test examiner was the between factor and the index category was the within factor. Out of the 188 students who were tested for special education services, 74 were tested by Examiner C and 112 by Examiner G. Two students were not included in this analysis because the data was incomplete due to not taking certain subtests of the WISC-IV. The ANOVA included three separate tests. The first was a main effect for index category assessment, the second was a main effect for test examiner, and the third was an interaction effect for test examiner by index category. The researcher was not interested in the results of the main effect for the index category assessment, because that was evaluated previously. The main effect for examiner score was not statistically significant (F = .848, *df* = 3, 303, *p* = .468). Although Examiner C IQ evaluations tended on average to be lower than Examiner G, the differences were not statistically significant. Therefore, they did not have affected the results of the study. The interaction effect for index category and test examiner for all students who were tested for the qualification for special education services showed no statistically significant differences between examiners across the four index scores (F = .848, *df* = 3, 303, *p* .468). The mean index scores for each examiner are shown in Table 13.

Table 13

Index Score Means by Examiner for All Students Tested for Special Education.

Index Category	Examiner	Mean
Verbal Comprehension	C	95.2162
	G	97.2946
Perceptual Reasoning	C	94.5676
	G	98.8661
Working Memory	C	92.0000
	G	92.7679
Processing Speed	C	88.4054
	G	90.9018

A two factor (one between and one within) ANOVA was used to determine whether the test examiners' influence caused a significant difference in index scores for the subgroup of students who qualified for Specific Learning Disabilities under Missouri criteria. The test examiner was the between factor and the index category was the within factor. Out of the 104 students who qualified as having Specific Learning Disabilities, 34 were tested by Examiner C, 69 by Examiner G, and one by another examiner. The analysis does not include the score recorded by the third examiner. The ANOVA included three separate tests. The first test was a main effect for index category, the second was a main effect for test examiner, and the third was an interaction effect for test examiner by category. The researcher was not interested in the results of the first test, because they were previously addressed during the other hypothesis tests. The interaction effect for index category and test examiner for all students who were tested for the qualification for special education services showed no statistically significant differences between examiners across the four index scores (F = 2.816, df = 3, 552, p = .096). The interaction between index category and test examiner for the students who qualified as having learning disabilities was not statistically significant. This indicated no statistically significant difference in the index category scores between the two examiners (F = .207, df = 3, 552, p .891). Table 14 displays the means for each index score according to test examiner. Students' mean scores under Examiner C are all lower than students' mean scores under Examiner G. Although the scores under Examiner C were lower, none of the differences were statistically significant.

Table 14

Index Score Means of Students who Qualified as having Learning Disabilities by Examiner

Index Category	Examiner	Mean
Verbal Comprehension	C	98.4706
	G	100.7101
Perceptual Reasoning	C	98.5588
	G	103.4348
Working Memory	C	94.9118
	G	97.9855
Processing Speed	C	91.3235
	G	94.7381

These findings lend additional reliability to the clinical research study hypothesis tests 1 and 3 and imply that the conclusion from these tests were not impacted by the test examiner.

Summary

In this chapter, the researcher explained the descriptive statistics of the sample, shared the results of the hypothesis testing, and discussed additional analyses. All findings and results were explained and reviewed to determine the significance of *Working Memory* index scores in comparison to other index scores. The researcher found a statistically significant difference between the scores of students tested for disabilities and those of students who qualified for Specific Learning Disabilities. In all cases, *Working Memory* and *Processing Speed* index scores were lower than those of *Verbal*

Comprehension and *Perceptual Reasoning*. In addition, gender was marginally significant. Males tended to score lower on the *Verbal Comprehension* index and higher on *Perceptual Reasoning*. According to additional analyses, the test examiners were not factors in the interactions between the scores. Examiner G evaluated higher than Examiner C, but was consistent throughout the index categories. In the next chapter, the researcher presents the findings in the literature, determines implications for practice, provides recommendations for future studies, and draws conclusions from the clinical research study.

Chapter Five

Interpretation and Recommendations

Students across America continue to struggle to meet state grade-level expectations in reading and mathematics. According to the National Center for Education Statistics (NCES) [2010], 38% of students in America scored at or above proficient on their state reading test in 2009 and 26% of students in America scored at or above proficient on their state mathematics test in 2009 (p. 1). In addition, "percentages of 4th-grade students performing at or above the *Basic*, at or above the *Proficient*, and at the *Advanced* achievement levels in reading showed no measurable change from 2007 to 2009" (NCES, 2010, p. 1). Low student performance causes many teachers to refer students for special education to determine if a disability impacts their performance. These students are often identified as "slow learners" or "slow processors." During this study, the researcher examined another factor which could contribute to student's lack of progress – working memory. The researcher examined whether working memory impacted students who were involved in the special education referral process, students who did not qualify as having learning disabilities and students who qualified as having learning disabilities. This chapter begins with a restatement of the problem, a declaration of the purpose of the study, and an explanation of the methodology. In the next part, the researcher sets out the major findings in addition to the review of literature, some implications for action, and several recommendations for further research.

Study Summary

This section will provide a summary of the study in four sections. The first section will review the problem and the second section will explain the purpose of the study. Third, a review of the methodology will be described and lastly, the major findings will be explained.

Overview of the problem.

Gathercole, Alloway, and other researchers have studied the effects of working memory on learning success. Alloway believes the best predictor of academic success to be a student's working memory capacity (2008b, p. 1). A lack of academic progress in the ABC School District's general education classrooms is causing students to be tested for special education services. These students may be affected by working memory deficits, which in turn may be the cause of their poor academic progress. The teachers and administrators in the ABC School district may not know the impact of working memory on students' learning.

Purpose statement.

The purpose of this study was is to determine if working memory significantly impacted the performance of students who were tested for inclusion in special education programs. There were four specific purposes researched during this study. All of these purposes involved the researcher examining the four index scores of the WISC-IV to determine if there were significant differences. The first objective determined if all students who were tested for special education services had working memory deficits. The second objective determined if students who did not qualified for special education services had deficits in working memory. The third determined whether students who qualify for a Specific Learning Disability under Missouri criteria had deficits in working memory. The final one determined if the gender of students with Specific Learning Disabilities affected their *Working Memory* index scores.

Review of the methodology.

In this study, the researcher used a quasi-experimental, quantitative-research design. The study's population consisted of all the students in the ABC School District who were evaluated for special education programs. The researcher used purposive sampling to define the sample of the 188 participating students, all of whom were given the WISC-IV during their evaluation for special education services during the 2009-2010 school year. After the data were compiled, they were entered into an Excel worksheet and input into SPSS PASW 18.0 for analysis. One-factor repeated measures (or within subjects) ANOVAs were conducted for research questions one, two, and three. A two factor (one between and one within) ANOVA was conducted for research question four. In addition, Tukey post-hoc analyses were utilized to specify which means were statistically different. Finally, additional analysis were conducted to determine if the test examiner had any impact on the WISC-IV scores of students tested for special education and those who qualified for a Specific Learning Disability.

Major findings.

The major findings in this clinical research study included the results of an examination of the differences in IQ index scores to determine if working memory significantly impacted students who were referred for special education services, students who did not qualify for special education services, and students who qualified for a Specific Learning Disability under Missouri criteria. *Working Memory* and *Processing*

Speed test results were significantly lower than *Verbal Comprehension* and *Perceptual Reasoning* scores. This showed that students who struggle in school enough to be referred for special education services have greater deficits in those two areas. Deficiencies in working memory and processing speed appear to affect their learning processes and make academic work more difficult.

The students who did not qualify for any disability were not affected by working memory and processing speed as the entire population of students tested. Students who qualified for a Specific Learning Disability were impacted by working memory and processing speed, but not to the degree of all the students who were tested for special education services.

The researcher also explored gender differences within the subgroup of students who qualified for a Specific Learning Disability. Although none of the findings associated with gender were statistically significant, they were marginally significant. The girls' *Verbal Comprehension* index scores were higher than those of boys. This showed that the girls were better at expressing themselves verbally than the boys. The boys' *Perceptual Reasoning* index scores were higher than those of the girls. The boys' *Perceptual Reasoning* index scores were the highest of all the scores. This showed that the boys were better at visual tasks than the girls. *Working Memory* index scores were not discrepant between girls and boys. Boys' *Processing Speed* index scores were lower than those of the girls. The data revealed that Boys' *Perceptual Reasoning* index scores and *Processing Speed* index scores were the most discrepant. This could be a cause for more boys to qualify for learning disabilities than girls. *Working Memory* index scores were also lower than *Verbal Comprehension* and *Perceptual Reasoning* index scores.

Although low *Working Memory* index scores impacted learning, the more prevalent impact seems to stem from *Processing Speed* index scores. An argument could be stated that working memory impacts the slow processing speed. For students with working memory deficits, this could impede their abilities to process information rapidly.

Findings Related to the Literature

Researchers have conducted numerous studies on the impact of working memory on learning and other factors that may contribute to a student's poor working memory. This section includes descriptions of similar findings found in some of those studies.

As discussed in chapter two, the term processing speed "refers to how quickly information moves through the information processing system and how efficiently simple cognitive tasks are executed over a sustained period of time" (Dehn, 2008, pp. 80 - 81). Typically, processing speed is measured when individuals are already able to complete a task successfully and when the task is easy to complete without extensive thinking or reasoning (Dehn, 2008, p. 81). Therefore, once students learn to complete tasks well, they are able to improve their speed because the information is manipulated more readily. Dehn claimed that this interconnection shows an "exceptionally strong relationship" between working memory and processing speed (Dehn, 2008, p. 81). If a student is unable to complete a task, the work pace will be much slower. In addition, if a student processes information slowly, keeping the information in the brain long enough to manipulate it in order to complete the task will be difficult. For example, once a normally-developing student knows how to count to 20, working memory is not used to complete this task. After initially learning the task, the student utilizes processing speed to count to 20 and often improves the ability with repetition.

The correlation between working memory and processing speed in adults was investigated in 1982 by Case, Kurland, and Goldberg. Case, Kurland, and Goldberg (1982) wanted to determine if the more difficult the task the slower the processing and recall of information (p. 386). They used a number-span test and a word-span test. These assessments were lists of either words or numbers, but instead of using real words (or numbers), Case, Kurland, and Goldberg (1982) replaced them with nonsense words like bim, boc, and rif (p. 387). In both cases, changing real words (or numbers) to nonsense words (or numbers) slowed down the adults (p. 387). With the counting, the adults slowed to the pace that a 6-year old would typically count (p. 387). Their processing speed was slower, because the adults had to manipulate the information first.

In another research study by Ackerman, Beier, and Boyle, working memory and processing speed were moderately correlated at .477 (as cited in Dehn, 2008, p. 81). Ackerman, Beier, Boyle, Case, Kurland, and Goldberg found that processing speed increased with age. Two other researchers, Fry and Hale, also found this to be true. They reported that "71% of the age-related changes in working memory capacity were related to the developmental changes in progressing speed" (as cited in Dehn, 2008, p. 81). According to Dehn (2008), plausible evidence exists to show that "processing and storage capacity of working memory is extremely dependent on the general speed of cognitive processing" (p. 81). The more quickly one processes information, the more likely one will remember it. Furthermore, if information is processed more rapidly, it "allows more efficient access to representation maintained in working memory" (p. 81).

On the contrary, in the case of a student who has a learning disability, working memory may impact learning more significantly than processing speed and vice versa.

Some students are able to process information more readily if they already know it, although manipulating it through their working memories may be challenging (ABC Special Educator, personal communication, May 2011). These students are quick to count after months of learning to count. Once they have the skill, they can process that information more rapidly. Other students have information in their brains which they cannot retrieve quickly. They make minimal progress on reading a passage fluidly, even if the passage's level of difficulty is several grade levels below that which they can decode and comprehend (ABC Special Educator, personal communication, May 2011).

Upon analyzing the study data, the wide range of index scores shows that working memory impacts both students who are referred for special education services and students who qualify as having learning disabilities. Additional information was provided that these students also typically struggle in the area of processing speed. Although the researcher did not look at the correlations between working memory and processing speed during this study, the findings may support the fact that these two could be linked due to not being statistically different. While this study provided information that students who qualify for special education services typically score poorly on working memory and processing speed, research articles were not found addressing this specific population, gender differences, or difference in the four index categories associated with IQ.

Conclusions

In this section of the paper, the conclusions are described. First the implications for action are provided to explain next steps the researcher should take to provide information and suggestions to the administration and test examiners in the ABC School

District. Next, the recommendations for future research are described and finally, the concluding remarks summarize the study.

Implications for action.

The results of this study have implications for action in the ABC School District. This study showed that working memory and processing speed were significantly impacting students in the ABC School District and are contributing to the students' referral for special education services. This information should help special education process coordinators and teachers to know what questions to ask about a student in Tier III to determine if there is a suspected disability. These questions will help the team determine if the student should be referred for special education testing. For example, does the teacher often repeat directions for the students or does the student understand the directions but takes more time to complete the task?

Although only marginally significant, the data showed that boys have larger discrepancies between index scores than girls. This might explain why more boys qualify for special education services. This study could also make educators more aware of the impact of working memory and processing speed on learning. Educators who observe students struggling with academics may not look past environment, lack of effort, or a lack of intelligence as the causes. If students qualify as having disabilities because of discrepancies in IQ and academic scores, working memory problems or processing speed deficits may be the root cause. If this is the case, educators should use accommodations to help these students achieve academically despite their processing deficit. This research should help the special education test examiners in ABC School District to reflect on their testing practices. Due to their test scores being consistently different, though not statistically significant, the test examiners may examine their practices and converse about test examination and scoring to improve practice.

Recommendations for future research.

The following recommendations are made for further research on students who are tested for admission to special education programs and the processing deficits that impact their learning. The first recommendation is to replicate this effort over multiple years. This would help confirm the consistency of these results over a period longer than a year. If the results are consistent over multiple years, further research about processing speed may need to be desirable.

The second recommendation is to conduct a study using another working memory measurement tool and compare it to the working memory subtest score on the WISC-IV to determine if results are consistent. This would deepen the reliability of this study and further research on the impact of working memory on academic performance.

The third recommendation is to analyze the WISC-IV and index scores when the index scores are so discrepant that the test examiner is able to figure a General Ability Index (GAI) score. A GAI score is reconfigured when one index score causes an undue influence on the other index scores because it is 19 points lower or more than the highest index score. In addition to the full-scale IQ score, the GAI score can be used as a "substitute…to determine eligibility for special education services and placement" (Rinard, Weiss, Rolfhus, Coalson, 2008, p. 2). For example, if a student's *Verbal Comprehension* index score is a standard score of 119 and the *Perceptual Reasoning* index score is a standard score of 100, then the 100 unduly influences the 119 and pulls down the overall IQ score. In this case, the examiner must reconfigure the GAI score.

The reconfigured GAI helps determine what the full-scale IQ score would be without the influence of the lower score (Perceptual Reasoning score of 100, in the example above). By looking at the GAI versus the index scores, it may be valuable to see how low working memory or processing speed are when there is a larger discrepancy between index scores. The fourth recommendation is to analyze the same research questions using the same research methods across multiple school districts. Determining whether commonalities exist among students' index scores when students are educated using different practices and curriculum would be interesting.

The last recommendation is to determine which students have working memory deficits based on their WISC-IV scores. Then, provide the students with an intervention to increase their working memory skills. From there, the researcher could measure students' progress on academic and working memory tasks and compare their academic and working memory scores to those of other students who have not had the intervention.

Concluding remarks.

This study examined *Working Memory* index scores in comparison to the other index scores on the WISC-IV: *Verbal Comprehension*, *Perceptual Reasoning*, and *Processing Speed*. Three groups of students were analyzed during this clinical research study: students who were referred for special education services, students who did not qualify for special education services, and students who qualified for a Specific Learning Disability according to Missouri criteria. After data were analyzed for the three groups, gender was investigated for the students who were referred for testing and the students who qualified as having a Specific Learning Disability.

Students who were referred for special education services were found to have a statistically significant difference among their *Working Memory* index scores and two index scores: *Verbal Comprehension* and *Perceptual Reasoning*. *Processing Speed* was also found to be significantly lower than *Verbal Comprehension* and *Perceptual Reasoning* index scores.

Students who did not qualify for special education services were not shown to have deficits in the area of working memory. All index scores were relatively commensurate to one another. A statistically significant difference between *Working Memory* and *Perceptual Reasoning* index scores and *Working Memory* and *Processing Speed* index scores existed for students who qualified as having learning disabilities. The results of *Verbal Comprehension* testing were not considered to be statistically significant. Further analysis was conducted to determine if gender influenced students' index scores. Boys were found to have the largest discrepancy between index scores. Boys' *Perceptual Reasoning* scores were higher than those of girls. Girls' *Verbal Comprehension* scores were higher than those of boys. *Working Memory* scores were similar between the two groups, and boys scored lower on *Processing Speed* index scores. The largest discrepancy existed between boys *Perceptual Reasoning* scores and their *Processing Speed* scores.

Overall, this clinical research study substantiates the statement that working memory probably impacts students with disabilities more often than it does students who do not qualify for special education services. This study also confirms that processing speed probably is a significant factor in the learning process. Further research should be conducted on the relationship between working memory and processing speed and on how to help students improve in these areas to ensure higher levels of learning for students with disabilities.

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Appendix A

Approval Letter to Conduct Research

SCHOOL OF EDUCATION
Baldwin City, Overland Park, Wichita, Topeka, Kansas City and Lee's Summit

June 1, 2011

Corey Porter
10812 East 58th Terrace
Raytown, MO 64133

BAKER UNIVERSITY
Own Confidence

Dear Ms. Porter:

The Baker University IRB has reviewed your research project application (M-0117-0221-0601-G) and approved this project under Exempt Review. As described, the project complies with all the requirements and policies established by the University for protection of human subjects in research. Unless renewed, approval lapses one year after approval date.

The Baker University IRB requires that your consent form must include the date of approval and expiration date (one year from today). Please be aware of the following:

1. At designated intervals (usually annually) until the project is completed, a Project Status Report must be returned to the IRB.
2. Any significant change in the research protocol as described should be reviewed by this Committee prior to altering the project.
3. Notify the OIR about any new investigators not named in original application.
4. Any injury to a subject because of the research procedure must be reported to the IRB Chair or representative immediately.
5. When signed consent documents are required, the primary investigator must retain the signed consent documents for at least three years past completion of the research activity. If you use a signed consent form, provide a copy of the consent form to subjects at the time of consent.
6. If this is a funded project, keep a copy of this approval letter with your proposal/grant file.

Please inform Office of Institutional Research (OIR) or myself when this project is terminated. As noted above, you must also provide OIR with an annual status report and receive approval for maintaining your status. If your project receives funding which requests an annual update approval, you must request this from the IRB one month prior to the annual update. Thanks for your cooperation. If you have any questions, please contact me.

Sincerely,

Carolyn Doolittle, EdD
Chair, Baker University IRB

UNDERGRADUATE CAMPUS | P.O. Box 65, Baldwin City, Kansas 66006
785.594.6451 | fax 785.594.2522 | www.bakerU.edu
GRADUATE CAMPUS | 8001 College Boulevard, Suite 100, Overland Park, Kansas 66210
913-491-4432 | fax 913-696-1997 | www.bakerU.edu

Appendix B

Institutional Review Board Submission

Date: 1/12/2011

School of Education **IRB PROTOCOL NUMBER ________________**

Graduate Department

IRB Request

Proposal for Research

Submitted to the Baker University Institutional Review Board

I. Research Investigator(s) (Students must list faculty sponsor first)

Department(s) School of Education Graduate Department

Name

1. Harold Frye, Major Advisor

2. Margaret Waterman, Research Analyst

Principal Investigator:

Corey Porter
Phone: 816-352-6377
Email: corey.porter@raytownschools.org
Mailing address: 10812 East 58th Terrace
Raytown, Missouri 64133

Faculty sponsor:

Dr. Harold Frye
Phone: 913-344-1220
Email: hfrye@bakeru.edu

Expected Category of Review: __x_Exempt __ Expedited ___Full

II: Protocol:

THE IMPACT OF WORKING MEMORY ON STUDENTS TESTED FOR SPECIAL EDUCATION SERVICES

Summary

In a sentence or two, please describe the background and purpose of the research.

The first purpose of this study is to determine if students who are referred for special education suffer from working memory deficits which impact their academic achievement. The second purpose is to determine if students who qualify for a specific learning disability have working memory deficits. The third purpose is to determine if students who do not qualify for a disability have working memory deficits.

The study is being conducted in the Raytown C-2 School District (referred to as ABC School District in the report of the study). The information found in this study may better equip educators with an eye for identifying working memory learning deficits. If educators are aware of profiles of students with deficits in working memory, educators may be able to determine programming for other students in Tier III prior to being referred for a special education evaluation.

Briefly describe each condition or manipulation to be included within the study.

There are no conditions or manipulations in this study.

What measures or observations will be taken in the study? If any questionnaire or other instruments are used, provide a brief description and attach a copy.

The dependent variable is IQ full scale scores and working memory index scores. The independent variable is whether or not the students qualify for special education. No questionnaires or other instruments will be utilized in the study.

Will the subjects encounter the risk of psychological, social, physical, or legal risk? If so, please describe the nature of the risk and any measures designed to mitigate that risk.

No, subjects will not encounter any psychological, social, physical, or legal risks in this study.

Will any stress to subjects be involved? If so, please describe.

No, subjects will not experience stress during this study. All data collected is historical.

Will the subjects be deceived or misled in any way? If so, include an outline or script of the debriefing.

No, subjects will not be deceived or misled in any way during this study.

Will there be a request for information, which subjects might consider to be personal or sensitive? If so, please include a description.

No personal or sensitive information will be collected. The archived information to be used in this study includes student's name (all student names will be replaced with randomly assigned numbers), full scale IQ score, IQ Index scores, and qualification for a disability. All data will be kept strictly confidential.

Will the subjects be presented with materials, which might be considered to be offensive, threatening, or degrading? If so, please describe.

No materials will be presented to the subjects for this study.

Approximately how much time will be demanded of each subject?

No time will be demanded of the subjects during this study.

Who will be the subjects in this study? How will they be solicited or contacted? Provide an outline or script of the information which will be provided to subjects prior to their volunteering to participate. Include a copy of any written solicitation as well as an outline of any oral solicitation.

The subjects in this study were students who were tested for a disability in the Raytown C-2 School District during the 2009-2010 school year. Students will not be solicited or contacted for this study. The deputy superintendent and the assistant superintendent of special services reviewed and approved the request for access to the archival data to conduct this research. The request to conduct research and the approval from the Raytown C-2 School District is included.

What steps will be taken to insure that each subject's participation is voluntary? What if any inducements will be offered to the subjects for their participation?

No subjects will be contacted for this study.

How will you insure that the subjects give their consent prior to participating? Will a written consent form be used? If so, include the form. If not, explain why not.

As no subjects will be contacted in this study, written consent is not necessary.

Will any aspect of the data be made a part of any permanent record that can be identified with the subject? If so, please explain the necessity.

All data utilized in the study will be coded for anonymity. No data from this study will be made part of any permanent record.

Will the fact that a subject did or did not participate in a specific experiment or study be made part of any permanent record available to a supervisor, teacher, or employer? If so, explain.

None of this information about the subjects participating will be made part of any permanent record available to a supervisor, teacher, or employer.

What steps will be taken to insure the confidentiality of the data?

To protect anonymity and insure confidentiality the psych-analyst in the Raytown C-2 School District will randomly assign a number to each student. All data provided to the researcher will remain confidential and will only be utilized by the researcher.

If there are any risks involved in the study, are there any offsetting benefits that might accrue to either the subjects or society?

There are no risks involved in this research study. The benefit of the study is the contribution to the research related to working memory and learning. Many educators are unaware of the impact of working memory. The findings of the study could provide pertinent information to educators about the impact of working memory on learning in the ABC School District. This information could potentially help them make more informed decisions about students who are struggling to make progress in the general education classroom.

Will any data from files or archival data be used? If so, please describe.

All data in this study is archival data. The archived information to be used in this study includes student’s name (all student names will be replaced with randomly assigned numbers), full scale IQ score, IQ Index scores, gender, and qualification for a disability. All data will be kept strictly confidential.

Appendix C

Institutional Review Board Approval

3-31-2011
Mrs. Corey Porter
School of Education Graduate Department
Baker University
RE: IRB: BU-2011-02: The Impact of Working Memory on Students Tested for Special Education Services
Dear Mrs. Porter:

The Baker University Intuitional Review Board (IRB) has reviewed your research project application (BU-2011-02) and approved this project under the Exempt category. As described, the project complies with all the requirements and policies established by Baker University for protection of human subjects in research. Unless renewed, approval lapses one year after approval date.

1. A Project Status Report must be filed with the IRB annually for continuation.
2. Any significant change in the research protocol must be reviewed and approved by the IRB prior to altering the project.
3. Any change in the investigator(s) named in the original application must be reviewed and approved by the IRB prior to altering the project.
4. Any injury to a subject because of the research procedure must be reported to the IRB immediately.
5. When signed consent forms are required:
a. the primary investigator must retain the forms until filed,
b. consent forms must be filed with the OIR with the annual report,
c. the subject must be given a copy of the form at the time of consent.
6. If this is a funded project, a copy of this letter must be with the grant file.

The Office of Institutional Research (OIR) must be notified when this project is completed or terminated. As noted above, you must provide an annual status report to receive approval for maintaining your project. If your project receives funding which requests an annual update, you must file your annual report at least one month prior to the annual update.

Thanks for your cooperation. If you have questions, please contact me.

Sincerely,
William R. Miller, Ph.D.
Chair, Baker University Institutional Review Board

CC: Harold Frye, Ed.D., Faculty Supervisor

Appendix D

School District Approval of Study

Dissertation Proposal

Name: Corey Porter

Date: March 1,2010

Topic: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed success on achievement testing in third grade students with a learning disability.

Proposal

As a requirement for the doctorate program through Baker University, I am proposing to write my dissertation on the effects of processing deficits on student achievement. I want to examine third grade students' IQ scores, who were tested for a learning disability between 2007 and 2010 to determine if students who qualify for a learning disability have similar strengths/weaknesses on the Weschler Intelligence Scale for Children-IV. In addition, I would like to correlate the WISC-IV scores with the students' Missouri Assessment Program scores to determine if one area is effecting student achievement more than another.

- I will not use Raytown's name in my dissertation.
- Although I will initially need students' names associated with the scores to match up the correlations, I will change the names to a number and shred the document with student names after matching the data.
- I will not use any student names in my dissertation.

I give Corey Porter permission to write her dissertation based upon the following proposal. I will allow her to use student IQ scores and Missouri Assessment Program data to conduct her research, under the guidelines listed above.

Dr. Janie Pyle, Deputy Superintendent of Raytown C-2 School District

Kim Bielawski, Superintendent of Special Services

Appendix E

Approval Letter of Dr. Staci Mathes

External Committee Member Nomination Form: Candidate Petition

Baker University Doctor of Education in Educational Leadership

Candidate: Corey Porter **Cohort:** 5 **Date:** August 28, 2011

Candidate's Major Advisor: Dr. Harold Frye

Assigned Committee Members:

1. Peg Waterman Research Analyst
2. Dr. Amy Wintermantel Baker Committee Member

Dissertation Topic or Title The Impact of Working Memory on Students Tested for Special Education Services

Recommended External Committee Member Nominee*: Dr. Staci Mathes
(cannot be a relative, spouse, significant other, or cohort colleague)

Degree and Position held by Nominee: Ed.D., St. Louis University

Director of Support Services, Raytown School District

Candidate's Affiliation with the Nominee: Formerly held the position candidate now holds; responsible for supervising Behavior Interventionists; responsible for Section 504 plans; former Process Coordinator.

Candidate's Rationale for Selecting the Nominee (include Nominee's area of expertise): Knowledge of Special Education and of processes in schools; has provided helpful support to the candidate in the completion of the dissertation.

Corey Porter 7/28/11

Signature of Candidate **Date**

Harold B. Frye 7/28/11

Approval of Major Advisor **Date**

Approval granted by members of the Graduate Education Department on 8/3/11 HBF

Date

Peggy Harris

Signature of Dean