EQUIPPING MINDS:
APPLYING A BIBLICALLY BASED CURRICULUM FOR IMPROVING WORKING MEMORY

A Thesis

Presented to

the Faculty of

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Doctor of Education

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by

Carol Thompson Brown

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APPROVAL SHEET

EQUIPPING MINDS:

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IMPROVING WORKING MEMORY

Carol Thompson Brown

Read and Approved by:

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Danny R. Bowen (Chair)

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John David Trentham

_____

Johnny Collett

Date_____

To Clayton

TABLE OF CONTENTS

Chapter Page

LIST OF ABBREVIATIONS

ASD	Autism spectrum disorder
ADHD	Attention deficit hyperactivity disorder
APA	American Psychological Association
AWMA-2	Automated Working Memory Assessment-2nd ed.
DSM-V	*Diagnostic and Statistical Manual of Mental Disorder-V*
EF	Executive functions
EMCDC	*Equipping Minds Cognitive Development Curriculum*
fMRI	Functional magnetic resonance image
FSIQ	Full scale IQ
Gc	Crystallized intelligence
Gf	Fluid intelligence
IEP	Individualized education plan
ID	Intellectual disability
IQ	Intelligence quotient
KBIT	Kaufman brief intelligence test
LTM	Long term memory
MLE	Mediated learning experience
NLD	Neurodevelopmental learning disorder
PET	Positron emission tomography
SCM	Structural cognitive modifiability
SLD	Specific learning disorder
STM	Short term memory

LIST OF TABLES

Table Page

LIST OF FIGURES

Figures Page

PREFACE

The journey of completing my doctorate began twenty-four years ago with the birth of my son, Clayton, who has had numerous learning challenges. Through the years my husband, Kyle, and I shed many tears and shared many times of joy as Clayton's journey included numerous therapies. In August of 2011, Clayton began his undergraduate degree at Boyce College and graduated in 2015. It was during this time that I met Garnetta Smith, who invited me to share with other students at Boyce College and SBTS the working memory, comprehension, and study skills Clayton had used to increase his cognitive abilities. I will forever be grateful for Garnetta's friendship and shared passion to help student's reach the potential God has for them.

In December of 2013, Alvin Hickey, a former professor at Boyce, encouraged my work with exceptional learners as we discussed exploring doctoral programs. Later, John David Trentham and Danny Bowen engaged me in the first of many conversations to begin the Ed.D. program and put the *Equipping Minds Cognitive Development Curriculum* through a true experimental research study. Bowen's continual refining of my thesis was painful at times but made me see this refinement as a blessing and a process needed to sit at the academic table and have a voice for those who have no voice.

In regard to the research study, I wish to extend my appreciation to the school, parents, and participants whose cooperation and commitment were exemplary. Furthermore, this study could not have been possible without four incredible mediators: Allison Borden, Michelle James, Leah Campbell, and Clayton Brown, who followed *EMCDC* with fidelity. As the data emerged, I am forever grateful to Jeffery Heath, who conducted the statistical analysis.

Kyle and I have worked together for over thirty years and this degree would not

have been possible if he had not released me and upheld me during this journey. The domestic duties of our household were assumed by my son Nolen, who has done all of the cooking and grocery shopping. Clayton and Ashley, our daughter, not only work as educational specialists at Equipping Minds, but as graduates of Boyce, they helped edit papers and shared textbooks. My parents, Dave and Fran Thompson, were also incredibly supportive in countless ways, as they have been for fifty-two years.

Through the years God has placed numerous individuals in my life to encourage my passion for helping learners with neurodevelopmental disorders. However, it has been the children I have worked with using *EMCDC* and the parents with whom I've cried and prayed, whose faces were continually before me when I felt discouraged; it was as if they were telling me, "Hard is good, Miss Carol." I am forever thankful to Kathy Meurer, who asked me to work with Rose and see her as any other student whose memory, processing, comprehension, and reasoning needed to be strengthened rather than as a child with Down syndrome. There are simply not words to express how Rose, Claire, Megan, Payton, Reagan . . . and numerous students and parents have inspired, taught, and encouraged me to embark and complete this journey.

If you read this research, I pray that you will see the need for the church and Christian educators to embrace the findings in neuroscience of cognitive modifiability for those with neurodevelopmental disorders. I pray you will see that a God-centered view of human development and the importance of human mediation are rooted in Scripture, for we are all created as the *imago dei* for His purposes and glory.

Carol Thompson Brown

Frankfort, Kentucky

December 2016

CHAPTER 1

RESEARCH CONCERN

Working memory is the new IQ. Over the last twenty years, research on working memory found reliable correlations between working memory span and several other measures of cognitive function, intelligence, and performance in school.[1] Recent studies on individual differences in mathematical abilities show that aspects of working memory contribute to early arithmetic performance.[2] Further studies examine the relationship between working memory, reading, and comprehension.[3] The key to intelligence is being able to put those facts together, prioritize the information, and do something constructive with it. Valerie Camos observes, "Working memory capacity refers to the ability to hold information in mind while maintaining other information to achieve a cognitive task."[4] Likewise, H. L. Swanson, O. Jermane, and X. Zheng state, "Working memory enables the retrieval of knowledge stored in long-term memory and its mental manipulation and application to foster the interpretation of novel information and

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[1]Tracy Packiam Alloway, *Improving Working Memory: Supporting Students' Learning* (Thousand Oaks, CA: Sage Publications, 2011), 10–14; Susanne M. Jaeggi et al., "Improving Fluid Intelligence with Training on Working Memory," *Proceedings of the National Academy of Sciences* 105 (2008): 6829–33, accessed December 15, 2015, http://dx.doi.org/10.1073/pnas.0801268105.

[2]Kimberly P. Raghubar, Marcia A. Barnes, and Steven A. Hecht, "Working Memory and Mathematics: A Review of Developmental, Individual Difference, and Cognitive Approaches," *Learning and Individual Differences* 20 (2010): 110–22.

[3]Barbara Carretti et al., "The Role of Working Memory in Explaining the Performance of Individuals with Specific Reading Comprehension Difficulties: A Meta-Analysis," *Learning and Individual Differences* 19, no. 2 (2009): 246–51. See also Rune Andreassen and Ivar Braten, "Examining the Prediction of Reading Comprehension on Different Multiple Choice Tests," *Journal of Research in Reading* 33, no. 3 (2010): 263–83.

[4]Valerie Camos, "Low Working Memory Capacity Impedes Both Efficiency and Learning of Number Transcoding in Children," *Journal of Experimental Child Psychology* 99 (2008): 38.

the solution of problems."[5] Working memory is the skill that gives an individual the advantage of managing all this information and is a stronger indicator of a learner's academic and personal potential than an IQ test.[6]

School curricula are focused on increasing the knowledge of subject content. Students with low working memory capacity are often seen as inattentive, unmotivated, or having lower intellectual ability.[7] The current treatments have been limited to remediation of content, learning strategies, accommodations, and medication.[8] These may have short-term benefits, but are not targeting the underlying cognitive deficits. Teachers, interventionists, and parents need to be given the methods and tools to improve students' working memory capacity.

The belief that cognitive abilities are fixed has been prevalent in the United States for many years.[9] An individual's intellectual ability has been measured by his or her "intelligence quotient" (IQ).[10] Proponents of this *fixist* point of view believe that change in functioning and behavior cannot be made beyond a certain level.[11] However, over the last two decades the field of neuroscience has used non-invasive technologies,

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[5]H. L. Swanson, O. Jermane, and X. Zheng, "Growth in Working Memory and Mathematical Problem Solving in Children at Risk and Not at Risk for Serious Math Difficulties," *Journal of Educational Psychology* 100, no. 3 (2008): 343–79.

[6]Tracy Packiam Alloway and Ross Alloway, *The Working Memory Advantage* (New York: Simon and Schuster, 2013), 16. See also Tracy Packiam Alloway and Ross Alloway, "Investigating the Predictive Roles of Working Memory and IQ in Academic Attainment," *Journal of Experimental Child Psychology* 106 (2010): 27.

[7]Tracy Packiam Alloway, Julian Elliott, and Susan Elizabeth Gathercole, "The Cognitive and Behavioral Characteristics of Children with Low Working Memory," *Child Development* 80, no. 2 (March/April 2009): 606–21.

[8]Reuven Feuerstein, Louis H. Falik, and Refael S. Feuerstein, *Changing Minds and Brains* (New York: Teachers College Press, 2015), 51.

[9]Robert Sternberg, foreword to *Cognitive Modifiability in Learning and Assessment,* ed. Oon-Seng Tan and Alice Seok-Hoon Seng (Singapore: Cengage Learning, 2008), vii.

[10]Vikram Patel, Lisa Aronson, and Gauri Divan, *A School Counsellor Casebook* (Manipal, India: Byword Books, 2013), 50.

[11]Robert J. Sternberg, "How Can We Teach Intelligence?" in *Educational Leadership* September 42, no. 1 (1984): 38.

such as the functional magnetic resonance image (fMRI) and positron emission tomography (PET), to show the plasticity of the brain, or *neuroplasticity*, which shows the brain's ability to heal, grow, and change.[12] These imaging techniques show brain activity during development and learning. According to Oon-Seng Tan and Alice Seok-Hoon Seng, "It is now increasingly recognized that the brain is not a static structure and is in fact a modifiable system that changes its physical and functional architecture in response to its complex interaction with its internal processes and the environment."[13] Since cognitive abilities are modifiable, how should this inform the way we help students improve their abilities to think and to learn? This is the crucial question before educators.

Introduction to the Research Problem

Recognizing that intelligence can be improved, educators can adapt their teaching to include students traditionally seen as difficult to teach, such as learners with neurodevelopmental learning disorders (NLD): intellectual developmental disorder or intellectual disability (ID), communication disorders, autism spectrum disorders (ASD), attention-deficit hyperactivity disorder (ADHD), specific learning disorders (SLD), and motor disorders. Research confirms the modifiability of the brain through experience and training as stated by Richard Davidson, neuroscientist at University of Wisconsin – Madison: "There is tremendous potential for plasticity and for change and for this new knowledge to transform the health care system and our entire education system."[14] Similarly, Miriam Boleyn-Fitzgerald says, "Neuroplasticity is the most important general discovery in all of neuroscience in the last decade. The brain is built to change in response to experience and in response to training. And it is really because of this active

[12]Miriam Boleyn-Fitzgerald, introduction to *Pictures of the Mind: What the New Neuroscience Tells Us about Who We Are* (Upper Saddle River, NJ: Pearson Education, 2010), xi.

[13]Oon-Seng Tan and Alice Seok-Hoon Seng, preface to *Cognitive Modifiability in Learning and Assessment*, ix.

[14]Boleyn-Fitzgerald, *Pictures of the Mind*, 21.

neuroplasticity that we can learn."[15]

Proposed Origin and Purpose of Structural Cognitive Modifiability

In line with neuroplasticity research in the twenty-first century, we now know that our brains are modifiable. The first program to increase intellectual performance for those with neurodevelopmental learning disorders was developed more than fifty years ago by Reuven Feuerstein, a clinical and cognitive psychologist who studied under Jean Piaget and Andre Ray in Geneva.[16] Piaget's theory stated that a person's intelligence was not only fixed, but that it developed in predictable stages at predetermined times with each stage needing to be mastered before moving to the next.[17] Educators, psychologists, and school counselors embraced Piaget's view.[18] Feuerstein, on the other hand, believed that intelligence was changeable and modifiable regardless of age, neurodevelopmental conditions, genetics, and developmental disabilities.[19] He also disagreed with the accepted concept of the *critical period* or *critical age*, which states that if a person has not reached a particular function by a certain age, he or she no longer has the ability to learn that skill. For example, while approximately seven years of age is the critical period for learning to speak, Feuerstein had a child who did not learn to speak until the age of nine and eventually learned to read and write.[20] According to Brian Boyd, "Feuerstein believed that when someone presents himself or herself as unable to

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[15]Boleyn-Fitzgerald, *Pictures of the Mind,* 22.

[16]Reuven Feuerstein, Refael S. Feuerstein, and Louis H. Falik, *Beyond Smarter: Mediated Learning and the Brain's Capacity for Change* (New York: Teachers College Press, 2010), 27.

[17]Jean Piaget, *The Child and Reality: Problems of Genetic Psychology* (New York: Grossman, 1973), 50–53.

[18]Patel, Aronson, and Divan, *School Counsellor Casebook*, 22.

[19]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 8–9.

[20]Ibid.

understand something, one does not make the assumption that he or she is unintelligent. Rather, it is assumed that the person's intelligence is lying dormant, and the process of mediation by a teacher allows that intelligence—that latent intelligence—to come to the surface."[21]

Feuerstein's theory is known as Structural Cognitive Modifiability (SCM). His theory of human development has three basic ideas:

1. Three forces shape human beings: environment, human biology, and mediation.
2. Temporary states determine behavior: How someone behaves—namely emotional, intellectual, and even habitually learned activities—represents a temporary state, not a permanent trait. This means that intelligence is adaptive. In other words, intelligence can change; it is not fixed once and for all.
3. The brain is plastic: because all behaviors are open and developing, the brain can generate new structures through a combination of external and internal factors.[22]

Feuerstein insisted that human cognitive abilities can be changed regardless of heredity, genetic disorder, chromosomal disorders, or a person's age, even if the neuro-developmental condition is generally considered irrevocable and irreparable. "Don't tell me what a person is," said Feuerstein. "Tell me how he is changeable!"[23]

Mediated Learning

The theory of Mediated Learning Experience (MLE) initially grew as part of Feuerstein's theory of Structural Cognitive Modifiability (SCM).[24] Mediation is an interaction in which a mediator who possesses knowledge intends to convey a particular

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[21]Brian Boyd, "Intelligence is Not Fixed," The Journey to Excellence website, Windows Media Player video file (August 31, 2007), accessed May 7, 2014, http://journeytoexcellence.org.uk/videos/expertspeakers/intelligenceisnotfixedbrianboyd.asp.

[22]Reuven Feuerstein et al., *The Feuerstein Instrumental Enrichment Program (*Jerusalem: ICELP Publications, 2006), 25–27.

[23]Reuven Feuerstein and Ann Lewin-Benham, *What Learning Looks Like: Mediated Learning in Theory and Practice, K-6* (New York: Teachers College Press, 2012), 30.

[24]Ibid., 27.

meaning or skill and encourages the child to transcend, that is, to relate the meaning to some other thought or experience. Mediation is intended to help children expand their cognitive capacity, especially when ideas are new or challenging.

MLE is a way of interaction which contrasts with Piaget's view. Piaget advocated for a natural progression of learning through direct exposure to stimuli, or the "stimulus-organism-response (S-O-R)" model, which holds that it is enough for a person to simply dialogue with nature and the environment for cognitive development to occur.[25] Piaget is correct in saying that when you explore on your own, a natural progression leads to a natural limitation. Feuerstein believes a human mediator is needed, or "stimulus-human-organism-human-response (S-H-O-H-R)," allowing the mediator to take the learner beyond the natural limitations to reaching his or her full cognitive potential. While Piaget and Feuerstein are both giants in the field of human development, their greatest differences are their beliefs in fixed versus changeable intelligence and the role of a human mediator in developing a child's intelligence.[26] Piaget did not believe that adults are any different from other objects that provide information, and thus they should not intervene in a child's activity. He believed in spontaneous development: "I will call it psychological—the development of the intelligence itself, what the child learns by himself, what none can teach him, and what he must discover alone."[27] Feuerstein, however, sees the human mediator as crucial for a learner's development.[28]

Educators who embraced Piaget's direct approach to learning believed that mediation is unnecessary and interferes with a learner's independence and sense of

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[25]Feuerstein, Falik, and Feuerstein, *Changing Minds*, 5–11.

[26]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 27.

[27]Piaget, *Child and Reality*, 2.

[28]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 27.

freedom.[29] These educators believe many learners with neurodevelopmental learning disorders (NLD) are unmodifiable.[30] However, educators who implement mediation into their teaching realize that students with NLD can learn and are modifiable.[31] The theory of Structural Cognitive Modifiability (SCM), using the Mediated Learning Experience (MLE) method and its practical application, the Instrumental Enrichment (IE) program, has been used in numerous research studies in different countries to increase the cognitive abilities of learners with neurodevelopmental learning disorders.[32]

Need of Study

The success of the research with the Instrumental Enrichment program affirms that cognitive skills can be developed in the classroom or clinical setting through a human mediator.[33] However, in recent years the majority of research has utilized computer software programs to enhance cognitive skills with a focus on working memory training.[34] In 2013, *Developmental Psychology* ran an article evaluating the claims of computer-based cognitive skill programs by Hulme and Melby-Lervag, who conducted a

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[29]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 28.

[30]Reuven Feuerstein and Yaacov Rand, *Don't Accept Me as I Am: Helping Retarded Performers Excel* (Arlington Heights, IL: Skylight, 1997), 5.

[31]Feuerstein, Falik, and Feuerstein, *Changing Minds*, 7.

[32]Alex Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities: A Multicenter Study using Feuerstein's Instrumental Enrichment–Basic program," *Research in Developmental Disabilities* 31 (2010): 551–59. See also D. M. Romney and M. T. Samuels, "A Meta-Analysis Evaluation of Feuerstein's Instrumental Enrichment," *Educational and Child Psychology* 18, no. 4 (2001): 19–34; A. Kozulin, "The Diversity of Instrumental Enrichment Application," in *Experience of Mediated Learning*, ed. A. Kozulin and Y. Rand (Oxford: Pergamon, 2000), 257–73.

[33]Kozulin et al., Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[34]Kenneth J. Kohutek, "The Children's Cognitive Enhancement Program: A Pilot Study," *Journal of Scholastic Inquiry: Education* 1 (October 2014): 166–67.

systematic meta-analysis review of the existing studies.[35] Hulme and Melby-Lervag concluded,

> Currently available working memory training programs have been investigated in a wide range of studies involving typically developing children, children with cognitive impairments (particularly ADHD), and healthy adults. Our meta-analyses show clearly that these training programs give only near-transfer effects, and there is no convincing evidence that even such near-transfer effects are durable. The absence of transfer to tasks that are unlike the training tasks shows that there is no evidence these programs are suitable as methods of treatment for children with developmental cognitive disorders or as ways of effecting general improvements in adults' or children's cognitive skills or scholastic attainments.[36]

The *Equipping Minds Cognitive Development Curriculum* (*EMCDC)* is a method of cognitive skill development based on the theory of Structural Cognitive Modifiability (SCM), Mediated Learning Experience (MLE), and a biblical worldview of human development. This study inquired into the cognitive modifiability of children with a NLD. Is it possible to use the *EMCDC* and the MLE method to raise the working memory and cognitive ability capacity of learners to an extent that has previously not been linked to learners with these disorders? This study investigated whether or not the *EMCDC* affects the working memory of learners using the MLE and *EMCDC* methods. Specifically, this study was interested in whether an increase in working memory would result in transfer effects within an educational setting, measured by standardized tests of academic attainment, of non-verbal and verbal abilities. The objective was to determine if learners with a NLD can be educated in a more efficient and satisfactory manner. An effective cognitive development program can equip learners to reach their full potential academically and personally. According to Melby-Lervag and Hulme,

> In contrast to their peers, learners diagnosed with intellectual disabilities (ID) often have problems with attention, perception, memory, problem solving, and logical thought. They are slower in learning how to learn and find it harder to apply what

[35]M. Melby-Lervag and C. Hulme, "Is Working Memory Training Effective? A Meta-Analytic Review," *Developmental Psychology* 49, no. 2 (2013): 270–91. See also H. L. Roediger and M. A. Pyc, "Inexpensive Techniques to Improve Education: Applying Cognitive Psychology to Enhance Educational Practice," *Journal of Applied Research in Memory and Cognition* 1 (2012): 242–48.

[36]Melby-Lervag and Hulme, "Is Working Memory Training Effective?" 283.

> they have learned to new situations or problems. Some professionals explain these patterns by asserting that children with intellectual disabilities (ID) have qualitatively different deficits in cognition or memory. Others believe that persons with ID move through the same stages of development as those without intellectual disorders, although at a slower rate, reaching lower levels of functioning overall.[37]

Some learners with NLD have normal to high intelligence and are affected only minimally. According to Feuerstein and Rand, these learners will function only somewhat slower than average in learning new skills and information.[38] Educational and research programs today often do not accept this basic fact. This belief can be seen in K-12 programs written for the education of children with ID. It is possible to split these programs and their approaches into three major groupings.

The first group follows a traditional approach where we find those who believe in full integration of all children in typical schools and classrooms, usually with an individual aide. The curriculum is adapted to suit the individual, as academics are a secondary focus to the exclusion of reading instruction beyond a basic functional level. The primary focus is on social adaptation, vocational, and daily living skills, according to Ann Nevin.[39]

The second group, as described by D. S. Katims, follows a progressive approach and believes that academic skills such as arithmetic and reading are crucial to survive and sees social skills as a secondary emphasis. This group tends to prefer specialized schools or separate classes within typical schools. When pupils are integrated this group tends to prefer the use of "resource rooms" and "pull outs" in order to teach basic reading, writing, and arithmetic skills. Early Intervention as a specific program and an Individualized Education Plan (IEP) are considered a basic necessity for every learner

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[37]Charlotte Hawkins-Shephard, "Mental Retardation," in *ERIC Digest E528* (Reston, VA: ERIC Clearinghouse on Disabilities and Gifted Education, September 1994), 3, ED 372593, ERIC.

[38]Feuerstein and Rand, *Don't Accept Me As I Am*, 27.

[39]Ann Nevin, "Lesson Plans to Teach Self-Determination across the K-12 Curriculum for Students with Learning Disabilities, Students with Mental Retardation, Students with Emotional Disabilities, and Students with Traumatic Brain Injury" in *Resources in Education* (Phoenix: Arizona State University West, June 2000), 1–6, ED443260, ERIC.

in this group. It should be noted here that neither of these basic groupings is exclusive. Many researchers and educators combine the two approaches in different ways.[40] Julie Lane and Quentin Kinnison, in *Welcoming Children with Special Needs*, follow a combined approach by informing Christian schools on the policies and procedures for developing a special needs program. The schools are encouraged to follow the public school model that focuses on remediation, accommodation, modification, and intervention.[41]

A third group, as discussed by Feuerstein and Rand, merges the goals of both of the above groups by emphasizing neither of those basic approaches but rather the idea of cognitive development as a goal in itself. A learner's social and intellectual development is interrelated.[42] The teacher is a mediator who invites the learner to identify a problem, to analyze it, to use inductive thinking processes to develop a strategy for its solution, and connect it to other knowledge networks. Teachers who apply these principles of mediation enable learners to find a greater level of success as independent and active learners.[43]

When learners with NLD enter higher education many will experience academic difficulties and are viewed as undisciplined and unmotivated. Student services for learners with NLD provide writing centers, extended time on test, and other accommodations. However, the underlying causes of these learning difficulties are not addressed.

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[40]D. S. Katims, "The Quest for Literacy: Curriculum and Instructional Procedures for Teaching Reading and Writing to Students with Mental Retardation and Developmental Disabilities," in *Mental Retardation and Developmental Disabilities* (Reston, VA: Council for Exceptional Children, 2000), 3–14, ED445454, ERIC.

[41]Julie M. Lane and Quentin P. Kinnison, *Welcoming Children with Special Needs* (Bloomington, IN: West Bow Press, 2014), 77–89.

[42]Feuerstein and Rand, *Don't Accept Me As I Am,* 139.

[43]Feuerstein, Falik, and Feuerstein, *Changing Minds*, 191–201.

The Benefit of Study

The implications for the church, Christian school practitioners, Christian higher education practitioners, Christian academicians and professionals, homeschool parents, adoption and foster care parents, and missionaries are substantial since intelligence can be developed when a mediator teaches and trains a learner. The author of this study, Carol T. Brown, conducted professional development workshops for each of these groups who express appreciation for the training in cognitive development, as this is a void in teacher education programs according to Vanessa Ruda.[44] With this in mind, consider the following,

1. This study may benefit local church leaders by providing educational materials and resources for developing a special-needs ministry in the church and providing an after school or summer program for children and adults to integrate spiritual formation and cognitive formation. There are approximately 54 million people in the U.S. that are affected by disability, with estimates of 80 percent who are unreached and do not attend a Christ-honoring church. Yet, less than 10 percent of the churches in the U.S. have an intentional disability ministry or outreach.[45]

2. This study may benefit Christian school practitioners to understand the benefit of mediated learning and cognitive developmental exercises. A combination of cognitive developmental exercises and curricular studies should result in significant advancement of both cognitive and domain-specific skills for all learners. The Christian school will no longer need to refer parents to public schools but will be able to include more students with NLD in the Christian school setting.

3. This study may benefit Christian higher education administrators, practitioners, and student service professionals who serve and teach students with NLD and those with undiagnosed learning struggles. Addressing the underlying deficits in working memory may increase student's academic satisfaction increasing student retention and graduation rates. As the number of adult learners is increasing in higher education, it is important to continue to engage in stimulating learning activities during adulthood to manage the demands on working memory.

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[44]"Without a doubt, the Improving Working Memory workshop you led at *Equipping Minds* was the single most influential, useful, professional development experience I have ever attended. This information was not included in my special education courses or professional development," said Ruda (Kentucky Special Education Teacher of the Year, 2013). Vanessa Ruda, interview by author, Danville, KY, November 1, 2014.

[45]Joni Eareckson Tada, *The Father's House*, DVD (Agoura Hills, CA: Joni and Friends, 2013), accessed June 22, 2015, https://beta.rightnowmediaatwork.org/Content/Series/514.

4. This study may benefit the Teacher Education Program at Boyce College, which aims at the following, "A degree in Teacher Education will prepare you for the challenges of teaching and leading in the field of education, Christian ministry, and international missions."[46] Brown was a guest lecturer at Boyce College on October 29, 2012 for the course Teaching Exceptional Learners.

5. This study may benefit Christian academicians and professionals in the fields of education, cognitive psychology, educational psychology, child and adolescent psychiatry, human development, social work, occupational therapy, and speech-language pathology who work with learners with NLD.[47] There are many Christian practitioners in these schools and organizations serving and teaching many Christian and non-Christian families.

6. This study may benefit homeschool parents. In 2013, the U.S. Department of Education's National Center for Education Statistics reported that approximately 1,770,000 students are homeschooled in the United States—3.4 percent of the school-age population. Among children who were homeschooled, 68 percent are white, 15 percent are Hispanic, 8 percent are black, and 4 percent are Asian or Pacific Islander.[48] The Home School Legal Defense Association has over 14,000 families who subscribe to the struggling learners newsletter.[49]

7. This study may benefit missionaries serving abroad and stateside who have children with NLD and desire to stay on the mission field. Many missionaries homeschool or place their children in schools in the country where they serve. There are limited services for children with NLD in many countries. A cognitive curriculum which parents can implement at home would allow them to continue fulfilling their calling and develop their child's cognitive abilities.[50] Missionaries will also be equipped to

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[46]Boyce College, *Teacher Education Program*, accessed January 16, 2016, http://www.boycecollege.com/academics/programs-of-study/teacher-education-program/.

[47]There are a psychologist and a pediatric audiologist, both in New York, as well as an occupational therapist and a speech-language therapist, both in Louisville, KY, who use *EMCDC* in their diverse private practices.

[48]J. Michael Smith, "U.S. Department of Education: Homeschooling Continues to Grow," *HSLDA* (September 3, 2013), accessed January 13, 2016, https://www.hslda.org/docs/news/2013/201309030.asp.

[49]Faith Berens, telephone interview with author, January 13, 2016.

[50]*EMCDC* is being used in a mission school in Tanzania and with missionary families in India, Romania, Paraguay, Ukraine, Uganda, Germany, Indonesia, Kenya, and China. Brown presented at the SHARE Education Services conference in Budapest, Hungary, in February 2016 for expatriate families including missionaries living in Europe. Stephanie Elmerick said, "At a time when I felt completely overwhelmed and isolated, Equipping Minds came along and provided us with help and encouragement via Skype. They took the time to help me understand their workbook so I could implement the games and activities at home. They seemed to understand our children's individual needs and struggles and would even read Scripture and pray with one of them when he was having a bad day. God has used them to give me hope where the educational needs of our children are concerned. For families living overseas and for the church in general, Equipping Minds is a tremendous resource, helping parents feel confident in their calling, and giving children courage and confidence as they improve their skills, literally equipping their

help other learners with NLD where they serve.

8. This study may benefit parents who have adopted or foster children with special needs and NLD. According to Karen Purvis, adopted and foster children can bring many challenges with them, including abandonment issues, neurological alternations, cognitive impairments, sensory processing deficits, and other struggles.[51] Adopted and foster children need guidance in learning to relate to others. Parents are encouraged to intentionally interact with their child.[52]

Relationship between Neuroscience and Scripture

This research assumes that cognitive psychologists have demonstrated that cognitive abilities can be modified in their research. The Feuerstein Institute has been conducting research for the last five decades.[53] Feuerstein's Instrumental Enrichment (FIE), a cognitive development program emphasizing critical thinking strategies, has been found to have positive effects on many types of learners.[54] Numerous studies have been completed, and more are in progress. These studies have encompassed many types of student populations.[55] Feuerstein begins his discussion of the two components of modifiable intelligence, the intellect and the emotion, with an unusual perspective, an expression of *faith*:

> This word, *faith,* is used despite the fact that from a position of *science* one has the inclination and training to divest oneself completely from such an "unscientific" term. But the point we wish to emphasize is that in the beginning there must be a *need*- a need that will generate the belief in human modifiability. I must have the need to have my students and those with who I am engaged reach higher potentials of functioning. This need energizes me to act and motivates my faith (belief) that there are positive, effective, and meaningful alternatives to be found, to fight for,

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minds for life and service in the Lord," Stephanie Elmerick, e-mail message to author, October 17, 2015.

[51]Karen B. Purvis, David R. Cross, and Wendy Lyons Sunshine, *The Connected Child* (New York: McGraw-Hill, 2007), 34.

[52]Ibid., 159.

[53]Tan and Seng, *Cognitive Modifiability,* 4–9.

[54]Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[55]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 419–59.

> and to bring this faith into being. I believe that the student is a modifiable being who is capable of change and capable of changing according to his or her will and decisions. Human beings' modifiability differentiates them from other creatures and, according to the Rabbinic Midrash, 'even from the angels.' Herein lies the main uniqueness of human beings.[56]

As a devout orthodox Jew and theist, Feuerstein believed that man was created as the *imago Dei*.[57] On the sixth day of creation, "God said, 'Let us make man in our image . . . . So God created man in His own image; in the image of God He created him; male and female He created them'" (Gen 1:26-27).[58] Man can be renewed in knowledge and in the image of his Creator, which involves the mind and heart.[59] The image of God includes the whole person, in structure and function.[60]

Many Christian educators embrace the words of the great theologian and father of modern education, John Amos Comenius, who stressed the need to educate the intellectually and physically handicapped. He pleaded for educators to respond to those with special needs with extra sensitivity.[61] He believed that all humans are created in the image of God and have the capacity to learn as stated in the following passage,

> It is evident that man is naturally capable of acquiring knowledge of all things since, in the first place, he is the image of God . . . . So unlimited is the capacity of the mind that in the process of perception, it resembles an abyss . . . . but for the mind, neither in heaven nor anywhere outside heaven, can a boundary be fixed. The means to wisdom are granted to all men, and he reaffirms the common character of learning potentiality in all of mankind. What one human being is or has or wishes or knows or is capable of doing, all others are or have or wish or know or are capable

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[56]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 6.

[57]Reuven Feuerstein and Ann Lewin-Benham, *What Learning Looks Like: Mediated Learning in Theory and Practice, K–6* (New York: Teachers College Press, 2012), 5–6. See also Shmuel Feuerstein, *Biblical and Talmudic Antecedents of Mediated Learning Experience Theory: Educational and Didactic implication for Inter-Generational Cultural Transmission* (Jerusalem: ICEP Publications, 2002), 6–13.

[58]All biblical quotations are from the New King James version.

[59]Anthony A. Hoekema, *Created in God's Image* (Grand Rapids: William B. Eerdmans, 1986), 26.

[60]Ibid., 69.

[61]Daniel Murphy, *Comenius: A Critical Reassessment of His Life and Work* (Portland, OR: Irish Academic Press, 1995), 87–89.

likewise.[62]

This biblically-informed anthropology is central to the current research.

Purpose Statement

The purpose of this study was to examine the effect of the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*) on working memory in students diagnosed with specific learning disorder (SLD),[63] a neurodevelopmental learning disorder, and whether an increase in working memory resulted in transfer effects within an educational setting, measured by standardized tests of academic attainment and non-verbal and verbal abilities. Additionally, this study explored gender and age differences.

Delimitations of the Study

This study had the following delimitations. First, the study was limited to a single school, familiar with Equipping Minds, for the research study. The school asked to be considered for the research study. Second, the learners participating in the study have a documented diagnosis of specific learning disorder (SLD) by a qualified professional who followed the eligibility criteria for determining the qualification for SLD. Third, all of the participants in the training group completed 30 hours of cognitive developmental training over a 7-week period for 60 minute sessions with a mediator trained in the *Equipping Minds Cognitive Development Curriculum.* While the recommended training with *EMCDC* is 60 hours, it was necessary to use an abbreviated format of the full program as the intervention was limited to 30 hours. As there were only seven weeks available in the remaining school year before the *TerraNova* testing in April, this seemed a necessary format.

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[62]Murphy, *Comenius*, 87.

[63]American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed. (Washington, DC: American Psychiatric Publishing, 2013), 66–74. This manual includes difficulties learning and using academic skills in the areas of reading, comprehension, mathematics, spelling, and written expression.

Research Questions

1. What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum*?
2. What, if any, are the effects of changes in working memory to academic ability in learners using the *Equipping Minds Cognitive Development Curriculum*?
3. What, if any, is the effect of working memory on non-verbal and verbal abilities?
4. What, if any, is the effect of gender of the learner on working memory using the *Equipping Minds Cognitive Development Curriculum*?
5. What, if any, is the effect of the participant's age on working memory using the *Equipping Minds Cognitive Development Curriculum*?

Terminology

Automated Working Memory Assessment 2nd ed. *(AWMA*-2*).* The *AWMA*-2 is an automated, computerized assessment. It is easy to administer and produces a detailed report of the student's working memory profile. The full assessment contains verbal short-term memory, verbal working memory, visuospatial short-term memory, and visuospatial working memory components.[64]

Attention deficit hyperactivity disorder (ADHD). In this common condition, patients are hyperactive, impulsive, or inattentive, and often all three.[65]

Autism spectrum disorder. James Morrison states, "It is a heterogeneous neurodevelopmental disorder with widely varying degrees and manifestations that has both genetic and environmental causes. The symptoms fall into three broad categories: communication, socialization, and motor behaviors. Sensory abnormalities occur in perhaps 90 percent of patients. Note that there are varying degrees of ASD, some of which received separate diagnoses and codes in *DSM*-IV but no longer do."[66]

Central executive. The most complex component of WM. It is an

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[64]Tracy Alloway, *Understanding Working Memory* (Thousand Oaks, CA: Sage, 2014), 16.

[65]James Morrison, *DSM-5 Made Easy: The Clinician's Guide to Diagnosis* (New York: The Guilford Press, 2014), 33.

[66]Ibid., 26.

attentional system overseeing the visuospatial sketch pad, episodic buffer, and phonological loop.[67]

Communication disorders. A child's delay in using spoken and written language, and even sign language is characterized by small vocabulary, grammatically incorrect sentences, and/or trouble understanding words or sentences. Language Disorder is a new category.[68]

Crystallized intelligence (*Gc*). Tracy Alloway and Ross Alloway describe it in this way, "The ability to access and use knowledge, experience, and skills stored in long-term memory and is measured by tests that are designed to assess a person's depth and breadth of knowledge of particular topics, such as general knowledge, vocabulary, and mathematics."[69]

Episodic buffer. It is assumed to hold integrated episodes or chunks in a multi-dimensional code. In doing so, it acts as a buffer store, not only between the components of WM, but also linking WM to perception and LTM. It is able to do this because it can hold multidimensional representations, but like most buffer stores it has a limited capacity.[70]

Executive function. "An umbrella term for the complex cognitive processes that serve ongoing, goal-directed behaviors. It includes the following elements: goal setting and planning, organization of behaviors over time, flexibility, working memory, and self-monitoring," according to Lynn Melzter.[71]

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[67]Alan Baddeley, "Working Memory: Theories, Models, and Controversies," *Annual Review of Psychology* 63 (2012): 1–29.

[68]Morrison, *DSM-5 Made Easy*, 46.

[69]Tracy Packiam Alloway and Ross Alloway, *Working Memory: The Connected Intelligence* (New York: Psychology Press, 2013), 17.

[70]Baddeley, "Working Memory," 16.

[71]Lynn Meltzer, *Executive Function in Education: From Theory to Practice* (New York: Guilford Press, 2007), 1–2.

Functional magnetic resonance imaging (fMRI). David Sousa says, "The technology helps to pinpoint the brain areas of greater and lesser activity. Its operation is based on the fact that when any part of the brain becomes more active, the need for oxygen and nutrients increases. A magnet is used and the computer colors the brain regions that are activated."[72]

Fluid intelligence (*Gf*). Alloway and Alloway say that it "refers to inductive and deductive reasoning in situations that don't allow for the use of prior experience but instead challenge the individual to adapt and develop novel ideas and strategies to succeed."[73]

Individualized education plan (IEP). Students who qualify for special education will receive an individualized education plan. Annual goals with individual benchmarks are written. Classroom strategies, accommodations, and services are provided.[74]

Intellectual disability (Intellectual Developmental Disorder). There is a fundamental deficit in the ability to think, for someone with an intellectual disability. This will be some combination of problems with abstract thinking, judgment, planning, problem solving, reasoning, and general learning. The overall intelligence level of these individuals, as determined by a standard individual test, will be markedly below average. This generally means an IQ of less than 70.[75]

Kaufman Brief Intelligence Test, 2nd ed. (*KBIT*-2). The *KBIT*-2 was developed by Alan Kaufman and Nadeen Kaufman to measure both verbal and nonverbal ability.[76]

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[72]David Sousa, *How the Brain Learns*, 4th ed. (Thousand Oaks: CA: Corwin Press, 2011), 3.

[73]Alloway and Alloway, *Working Memory*, 17.

[74]Jessica Broitman and John Davis, *Treating NVLD Children* (New York: Springer, 2013), 44–49.

[75]Morrison, *DSM-5 Made Easy*, 20.

[76]Alan Kaufman and Nadeen Kaufman, *Kaufman Brief Intelligence Test*, 2nd ed.

Motor disorders. The patient is slow to develop motor coordination. Some also have attention-deficit/hyperactivity disorder or learning disorders. Others repeatedly rock, bang their heads, bite themselves, or pick at their own skin or body orifices.[77]

Phonological loop. A component of working memory responsible for the temporary storage of speech-like information.[78]

Plasticity. The brain's ability to change structurally and functionally as a result of daily learning and experience over a lifetime.[79]

Positron-emission tomography (PET). "The first technology to observe brain functions, PET involves injecting the subject with a radioactive solution that circulates to the brain. The computer displays the concentration of radiation as a colored picture. The more active areas in reds and yellows, and the quieter areas in blue and green," according to Sousa.[80]

Specific learning disability (SLD). This may involve problems with reading, mathematics, or written expression.[81]

Structural cognitive modifiability (SCM). "All human characteristics, including personality, cognition, and behavior are modifiable states, regardless of etiology, age or severity of condition," explain Tan and Seng.[82]

TerraNova. A standardized academic achievement assessment for grade 2-12 in reading, mathematics, spelling, language, science, and social studies.[83]

(Bloomington, MN: PsychCorp, 2004), 1.

[77]Morrison, *DSM-5 Made Easy*, 43–44.

[78]Alan Baddely, Michael W. Eysenck, and Michael Anderson, *Memory* (New York: Psychology Press, 2014), 499.

[79]Sousa, *How the Brain Learns*, 299.

[80]Ibid., 2.

[81]Morrison, *DSM-5 Made Easy*, 52.

[82]Tan and Seng, *Cognitive Modifiability*, 1.

[83]The *TerraNova* measures reading, mathematics, science, social studies, spelling and

Verbal working memory. Tracy Alloway explains, "It is used to remember instructions, learn language, and perform comprehension tasks."[84]

Visual-spatial working memory. Alloway continues, "It is used to remember sequences of events, patterns, images, and math skills."[85]

Visuospatial Sketchpad. "A component of the Baddeley and Hitch model of working memory that is responsible for the temporary maintenance of visual and spatial information," according to David Wechsler.[86]

Wechsler Intelligence Scale for Children, 4th ed. (*WISC*-IV). A widely used measurement of cognitive abilities in school-age children and adolescents. Index scores are derived from a combination of selected subtests. The WISC-IV yields four index scores: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed.[87]

Working memory. It prioritizes and processes information, allowing you to ignore what is irrelevant and work with what is important. It holds on to information so you can work on it.[88]

Procedural Overview

This research design was a true quantitative experimental study of the effects on working memory when applying the *EMCDC* among learners with a diagnosed NLD

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language. *TerraNova*, 3rd ed. (Monterey, CA: Data Recognition Corporation/CTB, 2016), accessed August 1, 2016, http://www.ctb.com/ctb.com/control/ctbProductViewAction?p=products&productFamilyId=449&productId=745.

[84]Tracy Alloway, *Improving Working Memory: Supporting Students' Learning* (London: Sage Publications, 2011), 3.

[85]Alloway, *Improving Working Memory*, 3.

[86]Baddely, Eysenck, and Anderson, *Memory*, 502.

[87]David Wechsler, *Wechsler Intelligence Scale for Children: Administration and Scoring Manual*, 4th ed. (San Antonio: Harcourt Assessment, 2003), 1–3.

[88]Alloway and Alloway, *Working Memory Advantage*, 9.

of specific learning disorder.[89] The school administrator randomly allocated the participants to either the active control or the training group.[90] A minimum of 30 participants were obtained.

There was a training group who received the *EMCDC* in a small group for five days a week in 60 minute sessions, for a minimum of 30 hours over 7 weeks from a mediator trained in *EMCDC*. In addition to the training group, an active control group was also included; they received special education support in a small group for five days a week for 60 minute sessions, for a minimum of 30 hours, over 7 weeks from an interventionist. All participating learners continued to receive standard special educational support services as a result of their learning difficulties. Both groups were administered both a pre-test and a post-test, but cognitive developmental training with *EMCDC* was provided only to the training group.[91]

A school who serves learners with NLD and is familiar with the *EMCDC* asked to be considered for the study, which gave access to the population sample. A letter of introduction including initial information about the study was delivered in written format to the school and the parents of the potential participants. Parental consent was obtained for each learner to participate in the study. A working memory pre-test was completed using the *Automated Working Memory Assessment* 2nd ed. (*AWMA*-2) by the participants. A non-verbal and verbal ability pre-test was given using the *Kaufman Brief Intelligence Test* (*KBIT*-2). The participants' academic testing for 2014-2015 on the *TerraNova*, a standardized academic achievement assessment, was used. The learners

[89]Experimental designs allowed Brown to identify cause-and effect relationships. See Paul D. Leedy and Jeanne Ellis Ormrod, *Practical Research: Planning and Design* (Edinburgh Gate, England: Pearson Education, 2014), 226.

[90]Leedy and Ormrod, *Practical Research*, 211. Stratified random sampling has the advantage of guaranteeing equal representation of each of the identified strata.

[91]Leedy and Ormrod, *Practical Research*, 228. An active control group should have minimal effect on the dependent variable and provide better support for extraneous variables.

then complete 30 hours of cognitive developmental skills training with a mediator using *EMCDC*. Following the completion of the 30 hours of cognitive developmental skills training, the participants completed the working memory post-test using the *AWMA*-2, a non-verbal and verbal ability post-test using the *KBIT*-2, and the 2015-2016 *TerraNova* standardized academic achievement assessment.

The *AWMA*-2, an online working memory assessment, is standardized for children and adults. The test scores are automatically calculated and interpreted by the computer software.[92] The data was compiled, evaluated, interpreted, and reported by the author of this study. The *KBIT*-2 is standardized for children and adults. Test scoring is done manually. The *TerraNova*[93] is a standardized academic assessment for 2nd–12th grade students.

Research Assumptions

It was assumed that the qualified professional who diagnosed the participants followed the eligibility criteria for determining the qualification for a specific learning disorder (SLD), according to the administering booklet and scored it appropriately. Secondly, it was assumed the qualifications for a SLD was met. Also assumed was that the *AWMA*-2 was a valid instrument, correctly designed to measure levels of working memory. Thirdly, it was expected that the *TerraNova* (which was used) is a valid instrument, correctly designed to measure academic abilities, and that the *KBIT*-2 was a valid instrument, correctly designed to measure non-verbal and verbal abilities. Additionally, the statistician was assumed qualified to analyze the findings.

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[92]Tracy Alloway, *Alloway Working Memory Assessment Manual,* 2nd ed. (London: Pearson Education, 2011), 9.

[93]The school uses the *TerraNova 3 Survey* to measure reading, mathematics, science, social studies, and language. It is an abbreviated version of the complete battery and provides a general measure of academic achievement; in addition, the school uses the *TerraNova CAT Plus* to measure important skills in word analysis, vocabulary, language mechanics, spelling, mathematics computation.

CHAPTER 2

PRECEDENT LITERATURE

This research study examined the ability to increase working memory in learners with a specific learning disorder (SLD), a neurodevelopmental learning disorder, using the *Equipping Minds Cognitive Development Curriculum*. The current research was born out of a suggestion that children with neurodevelopmental learning disorders have low working memory (WM) scores. These learners would be likely to have difficulties in certain areas of everyday functioning, and these difficulties would also impact achievement at school. A review of the literature in the areas of WM, shows its development and its relationship to academic performance, which led to the relationship of WM to specific learning disorders (SLD). This chapter will review the precedent literature relevant to increasing working memory. The naturalistic foundation of human development by cognitive psychologists will be contrasted with a biblical-theological foundation for humanity, knowledge, human development, and mediation.

Naturalistic Worldview of Human Development

Many Christian educators have been looking at learners with neurodevelopmental disorders through Piaget's eyes rather than God's. Developmental theories have informed our perspectives, expectations, and limitations of learners who have intellectual, behavioral, and physical challenges. According to Brett Webb Mitchell,

> Human developmental theories are not theologically neutral. For according to these theories we are not first and foremost God's children, created in God's image. Instead, we become the sum of our many divided and disparate developmental categories. Depending on the developmental theory used, each theory is inextricably

> connected to certain assumptions both about the self, our relationship with one another and the means by which we grow, and about the particular ends to which we are growing. These assumptions may be contrary to, if not antagonistic toward, the practices of the church.[1]

Humanity

Mitchell asserts that Freud reversed Genesis 1:27 from "God created man in his own image," into "Man created God in his image."[2] God is seen as a projection of a child's understanding of the parent. Piaget states,

> The child begins by attributing the distinctive qualities of the divinity-especially omniscience and almightiness- to his parent and thence to men in general. Then as he discovers the limits of human capacity, he transfers to God, of whom he learns in his religious instruction, the qualities which he learns to deny to men.[3]

Knowledge

The ability to "know" is seen in many theories of human development. For example, Piaget's theory of "genetic epistemology" is the study of the meaning, origins, and formation of knowledge in human organisms.[4] His naturalistic views, which have significantly impacted educators understanding of human development, have been virtually unchallenged.[5] Piaget's theory of intellectual development has four distinct and progressive stages of development and can also be understood as peoples' intellectual

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[1]Brett Webb Mitchell, "Leaving Development Behind and Beginning Our Pilgrimage," in *Care for the Soul*, ed. Mark R. McMinn and Timothy R. Phillips (Downers Grove, IL: IVP Academic, 2001), 81.

[2]Ibid., 87.

[3]Jean Piaget, *The Child's Conception of the World* (Totowa, NJ: Littlefield, Adams, 1979), 268.

[4]Jean Piaget, *Genetic Epistemology* (New York: Columbia University Press, 1970), 12.

[5]Jonathan H. Kim, "Intellectual Development and Christian Formation," in *Christian Formation: Integrating Theology and Human Development,* ed. James R. Estep and Jonathan H. Kim (Nashville: B and H Publishing Group, 2011), 66.

ability regardless of their age.[6] Christian educators have come to accept the theories of human development embraced by the American educational system that discount spirituality and have a naturalist worldview. These developmental theories inform our curricula, determine who may or may not attend Christian schools, define what is normal, and identify one's cognitive potential based on an intelligence quotient (IQ), a static assessment.[7] Educational psychology and human and child development textbooks have been the primary guide for understanding learners and have historically begun with Piaget's theory on cognitive development.[8] Piaget's views are the most well-known, accepted, and influential. Piaget believed every learner was responsible for generating his own "logical structures." The progression and acquisition of these abilities resulted from a learner's successful interactions with the environment.[9]

This belief system led many to view learners with neurodevelopmental learning disorders as having a fixed limit to their cognitive abilities since they were not able to acquire these abilities on their own. This belief led to the different approaches for learners with developmental disorders. Julie Lane and Quentin Kinnison, in *Welcoming Children with Special Needs*, follow a combined approach by informing Christian schools on the policies and procedures for developing a special needs program. The schools are

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[6]Kim, "Intellectual Development and Christian Formation, 68–69.

[7]Reuven Feuerstein, Refael S. Feuerstein, and Louis H. Falik, *Beyond Smarter: Mediated Learning and the Brain's Capacity for Change* (New York: Teachers College Press, 2010), 127–28.

[8]Jeanne Ormrod, *Educational Psychology: Developing Learners*, 8th ed. (Upper Saddle River, NJ: Merrill Pearson, 2014), 25–37. In addition, a Neo-Piagetian theorist and Harvard professor, Kurt W. Fischer states, "It is important to note that people develop differently in separate domains on the basis of their experiences and interest, and their development continues far into adulthood in domains on which they focus." Kurt W. Fischer, Zachary Stein, and Katie Heikkinen, "Narrow Assessments Misrepresent Development and Misguide Policy," *American Psychologist* 64, no. 9 (2009): 595–600.

[9]Jean Piaget, "The Origins of Intelligence in Children*,"* in *Classic Edition Sources: Human Development*, 3rd ed., ed. R. Diessner (Dubuque, IA: McGraw-Hill, 2007), 98–103.

encouraged to follow the public school model that focuses on remediation, accommodation, modification, and intervention.[10]

Biblical Worldview of Human Development

The father of modern education and reformed theologian, John Amos Comenius developed a system of progressive instruction according to the stage of human development a learner had reached, which was a precursor to developmental psychology. Piaget states, "Comenius was the first to conceive a full-scale science of education."[11] While Piaget had great admiration for Comenius' work, he dismissed and misunderstood Comenius' biblical worldview. According to Jean Piaget, Comenius' seventeenth century views on metaphysics and theology as presented in *The Great Didactic* were not relevant in the twentieth century.[12]

Comenius presents the first principles of human development and instruction in *The Great Didactic* as he brings theology, education, and human development together. Chapter 1 titled, "Man is the Highest, the Most Absolute, and the Most Excellent of Things Created," admonishes the reader to, "Know thyself, O man and Know Me, Me the source of eternity, of wisdom and of grace; thyself, My creation, My likeness, My delight."[13] As man is the center of God's creation, Comenius believes, "Man is naturally capable of acquiring a knowledge of all things, since, in the first place

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[10]Julie M. Lane and Quentin P. Kinnison, *Welcoming Children with Special Needs* (Bloomington, IN: West Bow Press, 2014), 77–89.

[11]Jean Piaget, "The Significance of John Amos Comenius at the Present Time," in *John Amos Comenius on Education*, ed. Jean Piaget (New York: Teachers College Press, 1967), 1–3.

[12]Ibid., 4.

[13]*The Great Didactic of John Amos Comenius*, trans. M. W. Keatinge (1896; repr., London: Forgotten Books, 2012), 25.

he is the image of God."[14] Comenius' insights into the potential and unlimited capacity of the human mind truly was hundreds of years before his time, as well as the scientific discovery of neuroplasticity as he states, "The mind; neither in heaven nor anywhere outside heaven, can a boundary be fixed."[15] Comenius reminds the reader that God is not a respecter of persons, and no one should be excluded because of their intellect. He believed that those with weak intellects need assistance by a mediator: "We do not know to what uses divine providence has destined this or that man; but this is certain, that out of the poorest, the most abject, and the most obscure, He has produced instruments for His glory."[16]

Contrasting Naturalistic and Biblical Worldviews

A human's intellectual development, or capacity for rational thought, is present because we are created in the image of God.[17] This theological foundation is crucial as we look at how these areas are related. A biblical worldview of humanity asserts that the chief aim of man and all of creation is to glorify God.[18] The biblical metanarrative of creation, fall, redemption, and restoration in relationship to the *imago Dei* and cognitive development as found in the Bible will be explored.[19] Further areas of examination are the integration of the biblical view of knowledge, human development,

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[14]*Great Didactic of John Amos Comenius*, 41.

[15]Ibid., 42.

[16]Ibid., 66.

[17]Ibid., 77.

[18]James M. Hamilton, Jr., *God's Glory in Salvation through Judgment: A Biblical Theology* (Wheaton, IL: Crossway, 2010), 53.

[19]Ibid., 49.

and mediation.

Creation of Humanity

A creational view of human development includes genetic and physiological, cognitive, emotional, volition, and relational development.[20] In the creation account, God said, "Let Us make man in Our image, according to Our likeness; let them have dominion over the fish of the sea, over the birds of the air, and over the cattle, over all the earth and over every creeping thing that creeps on the earth. So God created man in His *own* image; in the image of God He created him; male and female He created them" (Gen 1:26). It continues, "For in the image of God He made man" (Gen 9:6). Theologians refer to this as the *imago Dei* or "the image of God in man." Daniel Akin says, "To be human means to be an image-bearer of God. In the Bible, the image of God extends dignity to all humans of varying ages, abilities, genders, and ethnicities."[21] Furthermore, Peter Gentry and Stephen Wellum state, "The covenant relationship between God and Man is not restricted to an elite sector within human society."[22]

A correct understanding of the *imago Dei* is the basis for truly Christian human relationships and our relationship with God. According to Gentry and Wellum, "God is the center of the universe and we humans find our purpose in having a right relationship to God and to one another. The first man and woman, however, rejected this way."[23] This rejection led to the fall of man.

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[20]Eric L. Johnson, "Human Development and Christian Formation" (class lecture, Human Development and Christian Formation, The Southern Baptist Theological Seminary, Louisville, KY, July 24, 2015).

[21]Daniel L. Akin, ed., *A Theology for the Church* (Nashville: B and H Publishing, 2014), 293–94.

[22]Peter J. Gentry and Stephen J. Wellum, *Kingdom through Covenant: A Biblical-Theological Understanding of the Covenants* (Wheaton, IL: Crossway, 2012), 197.

[23]Ibid., 138.

Fall of Humanity

At the fall of humanity, "The image of God was damaged but not destroyed. It was defaced, not erased . . . . Humans today still bear God's image, even if in a distorted and fallen way."[24] Abnormal human development emerged at the fall as seen in physical, cognitive, and biosocial damage. All humans are born in sin and shaped by a sinful world.[25] Man's intellect or cognitive development was effected by the fall as well.

Redemption of Humanity

Union with Christ enables the fulfillment of human development. Salvation is the appropriation of our union with Christ. Redemptive development or the process of sanctification impacts our thinking and emotional patterns.[26] Consider the following, "And we know that the Son of God has come and has given us an understanding, that we may know Him who is true; and we are in Him who is true, in His Son Jesus Christ. This is the true God and eternal life" (1 John 5:20; see also John 17:3). Jesus said, "You shall love the Lord your God with all your heart, with all your soul, and with all your mind" (Matt 22:37). God desires that we grow deeper in our relationship with him and that our thoughts, our actions, and our desires reflect Christ Jesus. We are also to put on the new self (Eph 4:24), and be transformed by the renewing of our minds (Rom 12:2).

Believers should be growing in our knowledge of God on a continual basis as God gives believers the cognitive ability to be "increasing in the knowledge of God" (Col

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[24]Akin, *Theology for the Church*, 294.

[25]Johnson, "Human Development and Christian Formation."

[26]Ibid.

1:10). Believers are part of the body of Christ, a biblical community and thus, "should have the same care for one another" (1 Cor 12:14-26). The parent-child relationship is valued in Scripture. The following passages exhort parents to mediate, teach, and train their children in the commandments of God. Proverbs 22:6 says, "Train a child in the way he should go." Deuteronomy 6:7 instructs parents, "Teach them [commandments] diligently to your children, and shall talk of them when you sit in your house, when you walk by the way, when you lie down, and when you rise up." In the New Testament, Paul exhorts, "Fathers, do not provoke your children to wrath, but bring them up in the training and admonition of the Lord" (Eph 6:4). All believers are called to holistic discipleship impacting cognition, volition, emotions, and relationships.

Restoration and Consummation of Humanity

Restoration of the image of God is an ongoing process in the Christian life. There are five passages which refer to the restoration of the image of God in believers (Rom 8:29; 1 Cor 15:49; 2 Cor 3:18; Col 3:10 and Eph 4:22-24). In addition, the Bible speaks of the full consummation of believers to the image of Christ (Rom 8:29; 1 Cor 15:49).[27] The Apostle Paul says, "Now I know in part, but then I shall know just as I also am known" (1 Cor 13:12). In similar hope, John states, "God will wipe away every tear from their eyes; there shall be no more death, nor sorrow, nor crying. There shall be no more pain, for the former things have passed away. Then He who sat on the throne said, 'Behold, I make all things new.' And He said to me, 'Write, for these words are true and faithful'" (Rev 21:4-5). These truths give hope to learners with NLD as there will be no disabilities in our glorified bodies.

[27]Akin, *Theology for the Church*, 294.

Integration of *Imago Dei*, Knowledge, Human Development, and Mediated Learning

Believers know God as creator and as redeemer. Because we are formed in the image of God, He gives us the ability to know Him and to reason about Him. Jeremiah prophesied, "And I will give them a heart to know me, that I am the Lord: and they shall be my people and I will be their God: For they shall return unto me with their whole heart" (Jer 24:7). According to John Calvin, "God says that he would give them a heart to know him. The word heart is to be taken here for the mind or understanding, as it means often in Hebrew. It indeed, means frequently the seat of the affections, and also the soul of man, as including reason or understanding and will."[28] Calvin goes on to say, "We cannot have a clear and complete knowledge of God unless it is accompanied by a corresponding knowledge of ourselves. This knowledge of ourselves is twofold: namely, to know what we were like when we were first created and what our condition became after the fall of Adam." [29]

Furthermore, Proverbs 1:7 states, "The fear of the Lord is the beginning of knowledge." Calvin states, "If you ask in what this whole edification consists which we are to receive thereby, in a word, it is a question of learning to place our trust in God and to walk in the fear of Him, and – since Jesus Christ is the end of the law and the prophets and the essence of the Gospel of aspiring to know no other aim but to know him." [30] It is

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[28]John Calvin, *Jeremiah 20-29, The John Calvin Bible Commentaries* (Auckland, New Zealand: Titus Books, 2012), 4304, Kindle.

[29]John Calvin, *Institutes of the Christian Religion*, ed. John T. McNeill, trans. Ford Lewis (Philadelphia: Westminster Press, 1960), 1:183.

[30]Wilhelm Niesel, *The Theology of John Calvin*, trans. Harold Knight (Philadelphia: Westminster Press, 1956), 27.

through our personal relationship with God that believers truly know God, not just acquire knowledge about God. This knowledge is transforming**.**

Knowing God results in mediating or instructing children differently, and teaching them both diligently and intentionally. The concept of having a mediator to assist and teach those who are weaker is rooted in Scripture, as well as both the Christian and Jewish communities. God says of Abraham, "For I have known him, in order that he may command his children and his household after him, that they keep the way of the Lord, to do righteousness and justice, that the Lord may bring to Abraham what He has spoken to him" (Gen 18:19). This active and deliberate approach is in direct contrast to Piaget's passive approach, as unmediated exposure to stimulus is meaningless for those with neurodevelopmental disorders. However, according to Shmuel Feuerstein, "Intensive exposure to mediational experience makes meaningful and pervasive changes in the individual's cognitive structures."[31]

Feuerstein, simultaneously a cognitive psychologist, a theist and devout orthodox Jew, believed that we are created in the image of God. While he did not always insert his strong religious beliefs in his general writings, they were the foundation for his theories of cognitive development as he would refer to these beliefs in his formal lectures and professional training.[32] The theistic foundations to MLE are found in *Biblical*

[31]Shmuel Feuerstein, *Biblical and Talmudic Antecedents of Mediated Learning Experience Theory: Educational and Didactic implication for Inter-Generational Cultural Transmission* (Jerusalem: ICEP Publications, 2002), 22. Kozulin said, "Shmuel Feuerstein is Reuven Feuerstein's younger brother. Shmuel worked for many years in the Ministry of Education as a supervisor of the Biblical studies in Israeli state-religious schools. At a rather advanced age he received his Ph.D. (see his book) and started teaching at Bar Ilan University and Ashkelon College. As far as I know Shmuel and Reuven started collaborating professionally only at the time of Shmuel's doctoral research." Alex Kozulin, e-mail to the author, December 31, 2015.

[32]Feuerstein, *Biblical and Talmudic Antecedents*, 6. See also Louis H. Falik and Refael S. Feuerstein, preface to *Changing Minds and Brains* (New York: Teachers College Press, 2015), xxiii–xxiv. According to Louis Falik and Refael Feuerstein, regarding the last work by Reuven Feuerstein, one objective of this book was, "To give voice to the influence of Judaic culture in the formation and

and Talmudic Antecedents of Mediated Learning Experience and Theory written by Shmuel Feuerstein, brother and colleague of Reuven Feuerstein. Shmuel Feuerstein expounds on the biblical foundations of the theory of Mediated Learning. He shows the relationships between events, religious precepts, and conduct with a modern psycho-educational theory. Shmuel Feuerstein reminds the reader that there is a strong emphasis on the process of identification in Judaism, and mediation is the means through which a sense of identity is instilled.[33] Shmuel Feuerstein states,

> There are a whole series of qualities and attributes related to God which the human being learns to aspire to. The individual is asked to act in the image of God as is stated: God made man in his image. This image becomes the rationale for identification with characteristics that are attributed to the image of God. Identification is not only an emotional, volitional or motivational act but is probably one of the first and strongest requirements placed on the Jewish person.[34]

Shmuel Feuerstein also agreed with Comenius on two matters. First, that as God's creation, all individuals, regardless of abilities should be treated with human dignity. As the prophet Malachi states, **"**Have we not all one father? Hath not one God created us" (Mal 2:10)? Secondly, he believes that mediation stretches the mind and the cognitive capacities of an individual to optimal limits and reasoning capacity. Shmuel Feuerstein states,

> Developing each individual's mental capacities is an end in itself but it is also an important religious value. Each individual is endowed by God with capacities which must be developed to the fullest in order to fulfil God's will and place one's abilities in the service of God.[35]

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development of Professor Feuerstein's lifework. He was deeply religious, has throughout his life brought his knowledge and familiarity with the philosophy and practice of his Judaism into his educational and psychological theories and his practices, and devoted his life to the transmission of his culture, again to benefit humankind."

[33]Feuerstein, *Biblical and Talmudic Antecedents*, 11.

[34]Ibid., 11–12.

[35]Ibid., 26.

Historical Overview of Memory

Developing one's mental capacities has been a valuable skill for thousands of years. According to Frances Yates, "In the ages before printing, a trained memory was vitally important; and the manipulation of images in memory must always to some extent involve the psyche as a whole."[36] The Greeks are credited with many inventions including the art of memory. Yates brings to mind how Cicero recalls the story of how Simonides invented the art of memory in *De oratroe.*[37] Simonides was dining at the house of Scopas, a wealthy nobleman, at Crannon in Thessaly. After Simonides recited a lyric poem composed for Scopas, he requested to leave the table and proceed outside. During his absence, the roof of the banquet hall collapsed, crushing everyone who remained at the table. Their relatives and friends wanted to bury them. However, the bodies were unrecognizable. Simonides was the only one able to identify them by his recollection of the place in which each of them had been reclining at table. The event led to the discovery of the importance of mental images to enhance memory. He determined that persons desiring to train their memory must select localities and form mental images of the facts they wish to remember and store those images in the localities. The most complete pictures are formed in our minds of the things that have been conveyed to them and imprinted on them by the senses, according to Douglas Herrmann and Roger Chaffin.[38]

Greeks continued to contribute to the understanding of memory, as Plato and Aristotle were the first memory theorists. Aristotle introduced the law of association and analyzed memory retrieval. He compared the brain to wax that receives and impresses images into the learner's memory. Like Plato and Aristotle, Augustine presented a theory

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[36]Frances Yates, *The Art of Memory* (London: Pimlico, 2007), 11.

[37]Ibid., 18.

[38] Douglas J. Herrmann and Roger Chaffin, *Memory in Historical Perspective: The Literature before Ebbinghaus* (New York: Springer-Verlag, 1988), 78–79.

that connected memories to emotions experienced during the event, according to Herrmann and Chaffin.[39]

Interest in memory would decline during the fifth century and not return until Aquinas in the thirteenth century. Aquinas agreed with Aristotle: "To think is to speculate with images."[40] The importance of the brain forming images continued with Comenius. He sees the foundation of knowledge and thoughts through the organs of sight, hearing, smell, taste or touch. Comenius acknowledges the wisdom of God in this process when he says,

> Who was able to arrange that the small mass of our brains should be sufficient to receive so many thousands of images . . . . which are daily multiplied as we daily see, hear, read, or experience something new, are all carefully stored up. What inscrutable wisdom of God lie here? . . . . and who will not marvel at this abyss of memory which exhaust all things, which give all back again, and yet is never overfull or too void?[41]

Though some argue that certain people are not capable of gaining knowledge, Comenius disagrees. He says, "It is scarcely possible to find a mirror so dulled that it will not reflect images of some kind, or for a tablet to have such a rough surface that nothing can be inscribed on it."[42] Yet he does acknowledge the natural differences found in learners' intellects. He exhorts teachers to meet these learners of weak intellects where they are by extending patience to help and strengthen their minds, so that they will not become discouraged but will reach the maturity God has for them.[43] In teaching them something new, knowledge must begin with illustrations from everyday life. First,

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[39]Herrmann and Chaffin, *Memory in Historical Perspective*, 6–7.

[40]Aristotle *De Anima*, trans. J. A. Smith, 431a 17.

[41]*Great Didactic of John Amos Comenius*, 45–46.

[42]Ibid., 86.

[43]Ibid., 89.

exercise the learner's senses, then form memories through images that lead to comprehension and discernment of the information.[44]

The scientific study of memory originated with Hermann Ebbinghaus in the late 1800s. He is credited with setting a standard of careful scientific work in psychology.[45] Implementing a scientific and systematic approach, he identified the complex relationships between memory and learning. The success of Ebbinghaus's method led to the development of other memory tests which included tests for measuring the span of visual apprehension, memory for digits, for lists of words, for sentences, and so on according to psychologist, Florence Goodenough.[46]

Another influential psychologist, William James, was also interested in knowing how long and how much information one could temporarily maintain. As early as 1892, in *Principles of Psychology,* William James stated, "Unlike the virtually unlimited amount of knowledge that can be stored in a person's secondary memory (long-term), only a small amount of information can be kept conscious at any one time in one's primary memory (short-term)."[47]

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[44]*Great Didactic of John Amos Comenius,* 135.

[45]David Tulsky and Donald Saklofske, *Clinical Interpretation of the WAIS-III and WMS-III* (San Diego: Academic Press, 2003), 29.

[46]Ibid., 30.

[47]William James, *Principles of Psychology* (New York: Holt, 1890), 645. See also Akira Miyake and Priti Shah, eds., *Models of Working Memory* (New York: Cambridge University Press, 1999), 10.

Working Memory

Sixty years later in 1956, William James' views on memory ignited cognitive psychologist, George Miller, to organize and study these memory systems. The concept of working memory, as it is understood today, is found in *Plans and the Structure of Behaviour*.[48] Miller, Eugene Galanter, and Karl Pribram state,

> When we have decided to execute some particular plan, it is probably put into some special state or place where it can be remembered while it is being executed. It may be somewhere in the frontal lobes of the brain. We should like to speak of the memory we use for the execution of our Plans as a kind of quick-access, 'working memory.'[49]

Miller is most known for "The Magic Number Seven, Plus or Minus Two," which states that most adults can store between five and nine items in their immediate memory. He recognized the importance of grouping or organizing the input sequence into units or chunks. Since the span is a fixed number of chunks, one can increase the number of bits of information that it contains simply by building larger and larger chunks, each chunk containing more information than before. This kind of recoding increases the bits per chunk, and packages the binary sequence into a form that can be retained within the span of immediate memory.[50]

Interest in the kinds of memory intensified during the 1960's, producing a wide range of memory models. Until 1968, memory models had primarily consisted of short-term and long-term memory. One key modification came when psychologists Richard Atkinson and Richard Shiffrin presented a multi-store model, which included three components: sensory memory, short-term memory, and long-term memory. In this model, information enters from the environment and is detected by the sense organs

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[48]George A. Miller, Eugene Galanter, and Karl H. Pribram, *Plans and the Structure of Behaviour* (New York: Holt, Rinehart and Winston, 1960), 65.

[49]Ibid.

[50]George A. Miller, "The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information," *Psychological Review* 63 (1956): 81–97.

where it enters the sensory memory stores. If the individual pays attention to the information, it enters the short term store or "working memory," capable of manipulating the information.[51] The information is held between 15–30 seconds in short term memory. After it is rehearsed repeatedly, it proceeds to long term memory. If rehearsal does not occur the information is not retained.[52] Their theory emphasized the importance of cognitive functions.[53] Figure 1 illustrates their flow of information.[54]

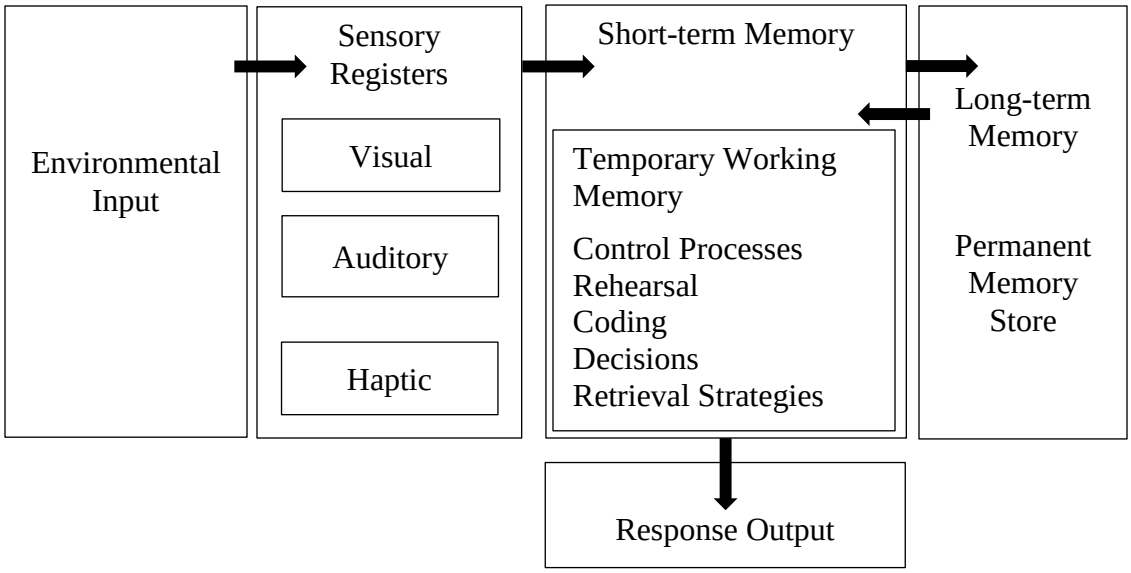

Figure 1. The flow of information through the memory system, Atkinson and Shiffrin

While the multi-store model introduced the controlled process of transferring

[51]R. C. Atkinson and R. M. Shiffrin, *The Control Processes of Short-Term Memory* (Stanford, CA: Institute for Mathematical Studies in the Social Sciences, Stanford University, April 19, 1971) 3–5. See also Alan Baddeley, *Essential of Human Memory* (New York: Psychology Press, 2014), 9.

[52]Ibid., 15.

[53]Oon-Seng Tan and Alice Seok-Hoon Seng, eds., *Cognitive Modifiability in Learning and Assessment* (Singapore: Cengage Learning, 2008), 20.

[54]Figure 1 is a re-creation of the display presented in R. C. Atkinson and R. M. Shiffrin, *The Control Processes of Short-Term Memory*, 3b. See also Alan Baddeley, *Essential of Human Memory* (New York: Psychology Press, 2014), 9.

information from short-term to long term memory, two studies showed this model to be incomplete. According to Tan and Seng, "First, the model assumed that the longer information was maintained in short-term memory, the more likely it was to be transferred to long-term memory."[55] The first study, by Shallice and Warrington, examined a patient with brain damage who had a profound repetition defect, with his digit and letter span being reduced to two items or less on short-term memory test. However, the long-term memory system and retrieval appeared normal.[56]

The second study, conducted by Craik and Watson on normal subjects, measured short-term memory storage times. Craik and Watson concluded that neither the duration of an item's stay or the number of times it was rehearsed in short-term memory was related to recall.[57] From this Craik and Lockhart argued against Atkinson and Shiffrin's multi-store model for a non-structured approach. They explored the "depth of processing" information where greater "depth" allows greater cognitive analysis. They proposed a "levels of processing" approach focused on the role of coding or manner of processing in learning and the probability of subsequent retrieval.[58]

Multi-Component Model of Working Memory

The UK Medical Research Council approved further research exploring the relationship between long and short-term memory in the early 1970s. [59] Psychologist

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[55]Tan and Seng, *Cognitive Modifiability*, 20.

[56]T. Shallice and Elizabeth Warrington, "Independent Functioning of Verbal Memory Stores: A Neuropsychological Study," *Quarterly Journal of Experimental Psychology* 22 (1970): 262.

[57]Fergus Craik and Michael Watkins, "The Role of Rehearsal in Short-Term Memory," *Journal of Verbal Learning and Verbal Behavior* 12 (1973): 599–607.

[58]Fergus Craik and Robert S. Lockhart, "Levels of Processing: A Framework for Memory Research," *Journal of Verbal Learning and Verbal Behavior* 11 (1972): 675.

[59]UK Medical Research Council is a government agency in the United Kingdom which funds Medical Research. Baddeley was the director of the Cognition and Brain Sciences Unit from 1974–1997.

Alan Baddeley and Graham Hitch asked the question, "What is short-term memory for?" There was a consensus that its function was to serve as a working memory, a system that allowed several pieces of information to be held in mind at the same time and interrelated."[60] The term "working memory" evolved from the earlier concept of short-term memory (STM). STM provides a temporary storage where WM provides storage and manipulation.[61] Baddeley and Hitch stated from the argument that working memory was a flexible and complex system with subcomponents.[62] They proposed the existence of a core system or central executive who controlled the entire system. The subsystems of the visuospatial sketchpad (visual) and the phonological loop (verbal) would assist the central executive system.[63] This multi-component model would be revised by Baddeley in 2000, and again by Baddeley, Allen, and Hitch in 2011; it is the most widely used model of working memory[64] and can be seen in figure 2.[65]

The Central Executive

According to Baddeley, "The central executive component of working memory is assumed to be a limited-capacity attentional system that controls the phonological loop and visuospatial sketchpad, and relates them to long-term memory."[66]

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[60]Alan Baddeley, *Essential of Human Memory* (New York: Psychology Press, 2014), 43.

[61]Alan Baddeley, "Working Memory: Theories, Models, and Controversies," A*nnual Review of Psychology* 63 (2012): 4.

[62]Alan Baddeley and Graham Hitch, "Working Memory," in *The Psychology of Learning and Motivation,* ed. G. A. Bower (New York: Academic Press, 1974), 8: 47–89.

[63]Ibid.

[64]Baddeley, "Working Memory," 1–29.

[65]Figure 2 is a re-creation of Baddeley's Model of Working Memory.

[66]Baddeley, *Essential of Human Memory,* 62.

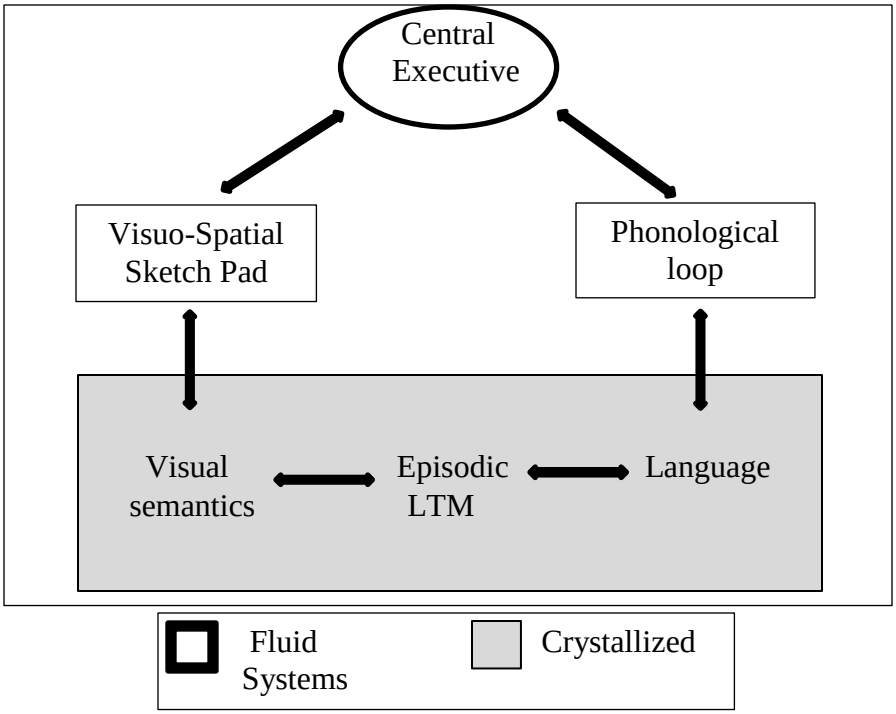

Figure 2. A modification of the original model to take account of the evidence of links between working memory and long-term memory

The Phonological Loop System

The phonological loop is the first storage system that stores and processes verbal information. It helps remember new words rather than recalling familiar words. The ability to form long-term representations of new phonological material is essential for the development of language. Learning new words impacts a child's cognitive development.[67] Successful vocabulary acquisition has been claimed to be the single most important determinant of a child's eventual intellectual and educational attainments.[68]

[67]Alan Baddeley and Susan Gathercole, "The Phonological Loop as a Language Learning Device," *Psychological Review* 105, no. 1 (1998): 158–59.

[68]Robert J. Sternberg, "Most Vocabulary is Learned from Context" in *The Nature of Vocabulary Acquisition,* ed. M. McKeown and M. Curtis (Hillsdale, NJ: Erlbaum, 1987), 89–90.

The Visuospatial Sketchpad

The visuospatial sketchpad is the second short-term storage system responsible for binding and storing visual and spatial information. It can be divided into separate components: visual, spatial, and haptic. The visuospatial sketchpad is involved in recalling information or tasks, such as remembering the face of someone you just met or the location of items at the grocery store.[69]

Episodic Buffer

The episodic buffer was added by Baddeley in 2000 and is the third storage system. It acts as a buffer store, not only between the components of working memory, but also links working memory to perception and long-term memory. It was developed to explain the interaction between the phonological loop and visuospatial sketch pad, in addition to how working memory communicates with long-term memory. In 2011 Baddeley noted that it represents a limited capacity, storing integrated chunks of information or episodes. It is accessible through conscious awareness.[70]

History of the Measurement of Intelligence

As man has been fascinated with memory, he has been equally fascinated with intelligence and the assessment of human cognitive abilities for thousands of years. Intelligence was first studied by Chinese emperors who used "large scale 'aptitude' testing for the selection of civil servants" circa 2200 B.C. [71] These proficiency tests were

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[69]Andrew Conway, Brooke Macnamara, and Pascale Engel De Abreu, "Working Memory and Intelligence," in *Working Memory the Connected Intelligence*, ed. Tracy Alloway and Ross Alloway (New York: Psychology Press, 2013), 23.

[70]Alan Baddeley, R. J. Allen, and Graham G. Hitch, "Binding in Visual Working Memory: The Role of the Episodic Buffer," *Neuropsychologia* 49, no. 6 (May 2011): 1393–1440.

[71]Alan Kaufman, *IQ Testing 101* (New York: Springer Publishing Company, 2009), 16.

given every three years. As the Chan dynasty began, candidates for public office were given a formal ability test.[72]

Intelligence Tests in the Eighteenth Century

Intelligence tests that examined the concepts of giftedness and intellectual disabilities began at end of the eighteenth century. The early pioneers were from France. First, Jean Esquirol explored the differences between mental illness and intellectual disabilities. He gave us the first modern mental test and was the first to label individuals as "idiots" based on this test.[73] Next, French physician, Jean-Marc Gaspard Itard, was recognized as one of the founding fathers of special education.[74] Itard is known for his work with the child referred to as "the Wild Boy of Aveyron."[75] He was the first physician to declare that an enriched environment could compensate for developmental delays caused by heredity or previous deprivation.[76] Until this time, it had been assumed that people with an intellectual disability were uneducable. Itard's work with Victor "did away with the paralyzing sense of hopelessness and inertia that had kept the medical profession and everybody else from trying to do anything constructive for mental defectives."[77]

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[72]Kaufman, *IQ Testing 101*, 16.

[73]Ibid.

[74]J. F. Gaynor, "The 'Failure' of J. M. G. Itard," *Journal of Special Education* 7, no. 4 (1973): 439–45.

[75]Jean Marie-Gaspard Itard, *The Wild Boy of Aveyron*, trans. G. Humphries and M. Humphries (Upper Saddle River, NJ: Prentice-Hall, 1962). In 1799 three French sportsmen found a young boy in the woods. He was taken to Paris where he could be studied as an example of the human mind in its primitive state. The famous psychiatrist, Philippe Pinel, viewed him as an incurable idiot. Itard disagreed. He believed that his apparent mental deficiency was entirely due to a lack of human interaction and this could be overcome. He brought the boy, whom he named "Victor," to The National Institution for Deaf-Mutes, and devoted the next five years to an intensive, individualized educational program. This was the first example of an IEP. While Victor improved, he never approached normalcy. After five years he could read and speak a few words, demonstrated affection for his caretakers, and could carry out simple commands.

[76]J. E. French, *Encyclopedia of Psychology*, ed. A.E. Kazdin, (Oxford: Oxford University Press, 2000), s.v. "Itard, Jean-Marie-Gaspard."

[77]Michael Horvath, Placido Arturo Hoernicke and Michael Kallam, "Mental Retardation in

Itard's influence was extended through the work of his pupil, Eduard Séguin.[78] Séguin improved and expanded Itard's sensory-training approach for those with intellectual disabilities. He developed methods of testing that were nonverbal and oriented toward motor activities and sensations based on Itard's work.[79]

Intelligence Tests in the Nineteenth Century

In the nineteenth century, scientists continued to study human intelligence. British scientist, Sir Francis Galton, studied the differences between monozygotic (identical) and dizygotic (fraternal) twins. His findings examined the nature versus nurture elements of mental abilities and leaned heavily on the genetic predisposition to abilities. He is recognized as the "father of behavioral genetics," or "differential psychology," the study of the differences in psychological traits. Galton was also the father of psychometrics.[80] He was the first to demonstrate that "normal distribution" could be applied to human intelligence. Galton demonstrated that mental abilities are distributed in a bell-shaped curve. He established the world's first mental testing center in which a person could take a battery of tests and receive a written report of the results on mental ability.[81] Galton's theory also stated that individuals take information through their senses, and intelligence would increase if sensory abilities could be increased.[82]

Perspective" (1993), 8–9, accessed August 15, 2015, ED 355729, ERIC.

[78]Kaufman, *IQ Testing 101*, 18.

[79]Ibid.

[80]Arthur Jensen, "Galton's Legacy to Research on Intelligence," *Journal of Biosocial Science* 34, no. 2 (April 2002): 145–48, accessed August 20, 2015, http://journals.cambridge.org/abstract_S0021932002001451.

[81]Ibid.

[82]Kaufman, *IQ Testing 101*, 20.

Intelligence Tests in the Twentieth Century

In 1904, Charles Spearman, a British psychologist, was the first to observe a pattern of positive correlations on various cognitive tests. Examining the grades of children in six academic disciplines, he conducted a statistical method called factor analysis. These six measurements could be reduced to correspond to a single mental ability known as a general factor, or Spearman's *g,* which continues to be used a century later.[83] In a study by P. C. Kyllonen on the individual differences in working memory capacity and psychometric intelligence (or Spearman's *g*), he observed, "This finding of the centrality of the working memory capacity factor leads to the conclusion that working memory capacity may indeed be essentially Spearman's g."[84] However, there are three main ideas of what *g* truly means: (1) *general* cognitive ability; (2) a reflection of the correlation among several different but related abilities; (3) a statistical artifact.[85] Spearman also introduced the *specific* factor which correlated to an individual's unique or specialized abilities.[86]

In 1905, Frenchman Alfred Binet, along with colleagues Victor Henri and Theodore Simon, produced the first intelligence test. Observing his two daughters, Binet noticed that the older daughter could perform tasks that the younger could not. These differences led him to the concept of "mental age," which examines the relationship between cognitive abilities and age. The Binet-Simon scale included many tasks: pointing to body parts, defining words, naming objects in a picture, repeating digits and complete sentences, describing the differences among similar items, saying a list of

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[83]David Z. Hambrick and Elizabeth J. Meinz, "Working Memory Capacity and Musical Skill," in *Working Memory the Connected Intelligence*, 145.

[84]P. C. Kyllonen, "Is Working Memory Capacity Spearman's *g*," in *Human Abilities: Their Nature and Measurement*, ed. I. Dennis and P. Tapsfield (Mahwah, NJ: Erlbaum, 1996), 73.

[85]Conway, Macnamara, and De Abreu, "Working Memory and Intelligence," 15–16.

[86]Tulsky and Saklofske, *Clinical Interpretation of the WAIS-III and WMS-III*, 16.

rhyming words in a minute, telling time on a reversed clock, and cutting a shape from a folded piece of paper. This scale was designed to deal with general intelligence. Binet recognized problems with the test and believed it should only be used as one part of determining intellectual functioning.[87] Binet states, "Some assert that an individual's intelligence is a fixed quantity which cannot be increased. We must protest and react against this brutal pessimism."[88]

Binet's assessment spread to the United States with H. H. Goddard and Stanford's Lewis Terman. By 1916, Terman had revised an American version and the "Stanford-Binet" was born. This new assessment was geared to American culture and was no longer limited to testing children but included adults. Terman presented a new total score called the "Intelligence Quotient (IQ)," which is used today.[89] In 1922, Terman stated, "There is nothing about an individual as important as his IQ, except possibly morals."[90] The Stanford-Binet had become the standard for IQ testing in the United States.

Intelligence testing spread during World War I as the U.S. Army used the assessment to determine who would be fit for military service. In 1917, David Wechsler, a student of Charles Spearman and Karl Pearson, began working for the army as a testing examiner using the Stanford-Binet scale to assess soldiers. The Stanford-Binet/Army Alpha system had a verbal scale and the Army Beta system had a performance scale.[91] Noticing the inadequacies in the assessment, Wechsler believed that the deficiencies

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[87]Conway, Macnamara, and De Abreu, "Working Memory and Intelligence," 18.

[88]David Shenk, *The Genius in All of Us* (New York: Random House, 2010), 34.

[89]Kaufman, *IQ Testing 101*, 24–25.

[90]Stephen J. Ceci, *On Intelligence: A Bioecological Treatise on Intellectual Development* (Cambridge, MA: Harvard University Press, 1996), 57.

[91]Tulsky and Saklofske, *Clinical Interpretation of the WAIS-III and WMS-III*, 20–27.

found in soldiers were due to a lack of education rather than a lack of intelligence.[92] In 1932, Wechsler began working as the chief psychologist at the Bellevue Psychiatric Hospital in New York. 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."[93] Wechsler believed it was necessary to measure verbal and performance intelligence, as well as global intelligence. This idea was revolutionary. The Wechsler-Bellevue scale was created in 1939 and developed into the Wechsler Intelligence Scale for Children (WISC) in 1949 and the Wechsler Adult Intelligence Scale (WAIS) in 1955. Both tests have been revised four times with the most significant change in the alternative set of summary scores organized into four domains of cognitive functioning: verbal comprehension, perceptual reasoning, working memory, and processing speed index.[94] The composite scoring and origin of the subtests are seen in table 1.[95] In 2003, shortly after Wechsler's death, the WISC-III was updated by the Pearson Company into a fourth edition. The WISC-IV was similar to the WISC-III, but was revised to reflect increased attention to working memory and processing speed.[96]

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[92]C. Boake, "From the Binet Simon to the Wechsler-Bellevue: Tracing the History of Intelligence Testing," *Journal of Clinical and Experimental Neuropsychology* 24, no. 3 (2002): 394.

[93]Tulsky and Saklofske, *Clinical Interpretation of the WAIS-III and WMS-III*, 26.

[94]Ibid., 51.

[95]Table 1 is a re-creation of the Origin of WISC-IV Subtests. Dawn Flanagan and Alan S. Kaufman, *Essentials of WISC-IV Assessment* (Hoboken, NJ: John Wiley and Sons, 2004), 7.

[96]Ibid., 1–2.

Table 1. Origin of WISC-IV subtests

Verbal Comprehension Index (VCI)	*Historical Source of Subtest*
Vocabulary	Stanford-Binet
Similarities	Stanford-Binet
Comprehension	Stanford-Binet/ Army Alpha
(Information)	Army Alpha
(Word Reasoning)	Kaplan's Word Context Test (Kaplan, 1950)
Perceptual Reasoning Index (PRI)	*Historical Source of Subtest*
Block Design	Kohs (1923)
Matrix Reasoning	Raven Progressive Matrices (1938)
Picture Concepts	Novel task (Psychological Corporation)
(Picture Completion)	Army Beta
Working Memory Index (WMI)	*Historical Source of Subtest*
Digit Span	Stanford-Binet
Letter-Number Sequencing	Gold, Carpenter, Randolph et al (1997)
(Arithmetic)	Stanford-Binet/ Army Alpha
Processing Speed index (PRI)	*Historical Source of Subtest*
Coding	Army Beta/Army Performance Scale
Symbol Search	Schneider & Schiffrin (1977)
(Cancellation)	

Correlation Between Working Memory and Intelligence

The measure of working memory capacity has a strong correlation to most intelligence tests. While a century has passed since the first IQ test was developed, there is still disagreement as to what intelligence really means, beyond a marker of an individual's intellectual ability.[97] In many theories of intelligence, a distinction is made between fluid and crystallized intelligence. Fluid intelligence comprises the set of abilities involved in coping with novel environments and especially in abstract reasoning. It is measured by tests of matrix problem, figural analogy, and classification. Crystallized intelligence is the product of the application of these processes and is measured by vocabulary and general information testing.[98]

In recent years "working memory" has been a key factor in determining fluid intelligence.[99] Numerous studies have shown that an individual's working memory capacity predicts performance in both language and mathematical skills on national curriculum tests.[100] Furthermore, low working memory capacities in children with or without learning disabilities result in academic difficulties.[101] Working memory is

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[97]Andrew Conway, Brooke Macnamara, and Pascale M. J. Engel de Abreu, "Working Memory and Intelligence: An Overview," in *Working Memory: The Connected Intelligence*, ed. Tracy Alloway and Ross Alloway (New York: Psychology Press, 2014), 12.

[98]Robert J. Sternberg, "Increasing Fluid Intelligence is Possible After All," *Proceedings of the National Academy of Sciences* 105, no. 19 (May 13, 2008): 6791–92, accessed August 20, 2015, http://www.pnas.org/content/105/19/6791.full.pdf.

[99]Jill Talley Shelton et al., "The Relationships of Working Memory, Secondary Memory, and General Fluid Intelligence: Working Memory is Special," *Journal of Experimental Psychology* 36, no. 3 (May 2010): 813.

[100]S. E. Gathercole, S. J. Pickering, and C. Knight, "Working Memory Deficits in Children with Low Achievements in the National Curriculum at 7 years of Age," *British Journal of Educational Psychology* 70 (2000): 177–94. See also S. E. Gathercole et al., "Working Memory Skills and Educational Attainment: Evidence from National Curriculum Assessments at 7 and 14 years," *Applied Psychology* 18 (2004): 1–16; R. LePine, P. Barrouillet, and V. Camos, "What Makes the Working Memory Spans So Predictive of High- Level Cognition?" *Psychonomic Bulletin and Review* 12 (2005): 165–70.

[101]R. Bull, R. S. Johnston and J.A. Roy, "Exploring the Role of the Visual–Spatial Sketch Pad and Central Executive in Children's Arithmetical Skills: View from Cognition and Developmental Neuropsychology," *Developmental Neuropsychology* 15 (1999): 421–42; R. Bull, and G. Scerif, "Executive Functioning as a Predictor of Children's Mathematics Ability: Inhibition, Switching, and Working Memory," *Developmental Neuropsychology* 19 (2001): 273–93; D. C. Geary, M. K. Hoard, and C. O. Hamson, "Numerical and Arithmetical Cognition: Patterns of Functions and Deficits in Children at

considered the "workbench of cognition" and directly impacts an individual's performance on high-level cognitive activities; working memory is a good predictor of human cognitive functioning.[102]

WISC IV Working Memory Index

The Working Memory Index (WMI) on the WISC-IV is comprised of three subtests: digit span forward, digit span backward, and letter-number sequencing. For the digit span forward, examinees are required to recall a series of numbers presented to them by the examiner. For the digit span backward, the examinee is presented with a series of numbers and is required to repeat them in reverse order. The new subtest, letter-number sequencing (LNS), requires examinees to recall numbers in ascending order and letters in alphabetical order from a given number and letter sequence. The intention of the Working Memory index score is to determine how well the student gains information, manipulates it, and produces the correct answer.[103]

Alloway Working Memory Assessment, 2nd ed. (*AWMA*-2)

The *Alloway Working Memory Assessment*, 2nd ed. (*AWMA*-2) was developed by Tracy Packiam Alloway. Alloway reported that the WISC-IV and *AWMA*-2 are highly correlated.[104] The *AWMA*-2 is a fully automated computer-based assessment of working memory skills standardized for learners ranging from five years to 79 years of age. There

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Risk for a Mathematical Disability," *Journal of Experimental Child Psychology* 74 (1999): 213–39. See also Valerie Camos, "Low Working Memory Capacity Impedes Both Efficiency and Learning of Number Transcoding in Children," *Journal of Experimental Child Psychology* 99 (2008): 37–57.

[102]Nelson Cowan, *Working Memory Capacity* (New York: Psychology Press, 2005), 3. See also C. Jarrold, and J. N. Towse, "Individual Differences in Working Memory," *Neuroscience* 139 (2006): 39–50; Camos, "Low Working Memory Capacity," 37–38.

[103]Flanagan and Kaufman, *Essentials of WISC-IV Assessment*, 410–13.

[104]Tracy Alloway, *Improving Working Memory: Supporting Students' Learning* (London: Sage Publications, 2011), 29. See also *Alloway Working Memory Assessment Manual*, 2nd ed., 16.

are three versions of *AWMA*-2: (1) *AWMA*-2 Screener: two working memory tests; suitable for screening individuals with suspected working memory difficulties; (2) *AWMA*-2 Short Form, which comprises four tests; recommended to screen individuals who are suspected to have memory difficulties, but the specific area of their difficulties is not known; (3) *AWMA*-2 Long Form: all eight tests; recommended for confirmation of significant working memory problems.[105] Table 2 illustrates the eight tests which comprise the *AWMA*-2. [106]

Table 2. Test included in the *AWMA*-2

VERBAL STM	*VERBAL WM*
Digit Recall	Backward Digit Recall
Letter Recall	Processing Letter Recall
VISUOSPATIAL STM	*VISUOSPATIAL WM*
Dot Matrix	Mr X
Block Recall	Backward Dot Matrix

Neurodevelopmental Learning Disorders and Working Memory

Over the last forty years, research on working memory has provided a deeper understanding of developmental cognition and neurodevelopmental disorders. Working memory deficits impact all learners with a NLD. [107] According to the *DSM*-5, "The

[105]Alloway, *Improving Working Memory*, 6.

[106]Table 2 is a re-creation of the eighth test on the *AWMA*-2.

[107]Tracy Alloway, "Introduction," in *Working Memory and Neurodevelopmental Disorders,* ed. T. P. Alloway and S. E. Gathercole (London: Psychology Press. 2006), 1–2.

disorders are characterized by developmental deficits that produce impairments of personal, social, academic, or occupational functioning. The range of developmental deficits varies from very specific limitations of learning or control of executive functions to global impairments of social skills or intelligence."[108] There are six categories of NLD with varying diagnostic criteria.

Attention Deficit Hyperactivity Disorder (ADHD)

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder defined by inappropriate levels of inattentive and/or hyperactive/impulsive behaviors that persist across more than one environment. ADHD is typically characterized by three subtypes including hyperactive-impulsive behavior, inattention, or a combination of these behaviors. The primary cognitive impairments associated with ADHD are deficits in executive functioning, in particular behavioral inhibition, which involves suppressing a prepotent (automatic) or irrelevant response.[109] Individuals with ADHD typically perform within age-expected levels for verbal short-term memory; however, they fall below the average range in measures of verbal working memory and visuospatial short-term memory and working memory. This profile is consistent with previous findings that visuospatial deficits are more marked than verbal ones as they are less automatic and so demand more cognitive resources.[110]

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[108]American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed. (Washington, DC: American Psychiatric Publishing, 2013), 31.

[109]*Alloway Working Memory Assessment Manual*, 26.

[110]Tracy Alloway, J. Elliott, and M. Place, "Investigating the Relationship between Attention and Working Memory in Clinical and Community Samples*," Child Neuropsychology* 16 (2010): 242–54. See also T. P. Alloway, S. E. Gathercole, and J. Elliott, "Examining the Link between Working Memory Behaviour and Academic Attainment in Children with ADHD," *Developmental Medicine & Child Neurology* 52 (2010): 632–36.

Autistic Spectrum Disorder (ASD)

Autism spectrum disorder was revised in the *DSM*-5.There was a spectrum of clinical profiles associated with this diagnosis ranging from autism, Asperger syndrome, and pervasive developmental disorder not otherwise specified (PDD-NOS) which are now integrated into the broad category of ASD.[111] General ability (measured by IQ tests) plays an important role in determining where an individual falls in this spectrum. Students with ASD perform within age-expected levels for visuospatial, short-term and working memory. However, they fall below the average range in measures of verbal short-term memory and working memory. This profile is consistent with the idea that verbal memory may be linked to deficits in communication.[112]

Intellectual Disability (Intellectual Developmental Disorder)

An intellectual disability includes deficits in intellectual and adaptive functioning in conceptual, social, and practical domains. The term *intellectual disability* replaces the term *mental retardation*. There are four levels of severity which include mild, moderate, severe, and profound.[113] An IQ score of 65–75 (70 + or – 5) is the criterion for the diagnosis and further assessments by a clinician are needed to determine the severity level.[114]

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[111]Lourie W. Reichenbe, *DSM-5 Essentials: The Savvy Clinicians Guide to the Changes in Criteria*, (Hoboken, NJ: John Wiley and Sons, 2014), 17.

[112]S. Belleville et al., "Working Memory in Autism," in *Working Memory and Neurodevelopmental Disorders*, ed. T. P. Alloway and S. E. Gathercole (London: Psychology Press. 2006), 213–38.

[113]American Psychiatric Association, *Diagnostic and Statistical Manual*, 33. Public Law 111–256 (Rosa's Law) replaced "mental retardation" with "intellectual disability."

[114]Ibid., 33–37.

Communication Disorders

Specific language impairment (SLI) is a relatively common communication disorder, also known as developmental language disorder, language delay, or developmental dysphasia. It is estimated to occur in approximately seven percent of the population, with boys being more affected than girls. It is characterized by a disproportionate difficulty in learning language despite having normal hearing, normal intelligence, and no known neurological or emotional impairment. [115] SLI children typically have below-average performance in tests of verbal short-term memory and working memory.[116] Their visuospatial memory skills are not impaired and performance is at the same levels as their peers in tests of both visuospatial, short-term memory and visuospatial working memory. This suggests that the difficulty that SLI children have in processing and storing information is specific to the verbal domain.[117]

Motor Disorders

"Motor disorders" replaces the previous categories of developmental coordination disorder (DCD) and tic disorders.[118] Motor disorders refer to individuals who have a marked impairment in motor skills that affect daily activities at home and in the classroom. DCD is present from birth and affects the individual's ability to plan and control movements, which can lead to associated problems with language and perception. The typical memory profile of individuals with DCD indicates that they are able to cope with tests involving short-term storage of verbal information.[119] However, once they also

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[115]*Alloway Working Memory Assessment Manual,* 23.

[116]L. M. D. Archibald and S. E. Gathercole, "Short-Term and Working Memory in Children with Specific Language Impairments," *International Journal of Language and Communication Disorders* 41 (2006): 675–93.

[117]*Alloway Working Memory Assessment Manual,* 23.

[118]Reichenbe, *DSM-5 Essentials,* 20.

[119]Tracy Alloway and K. J. Temple, "A Comparison of Working Memory Profiles and Learning in Children with Developmental Coordination Disorder and Moderate Learning Difficulties,"

have to process verbal information, their performance drops as they struggle with the combination of processing and storing information as part of the verbal working memory tests. The most striking deficits are evidenced in visuospatial memory tests where they perform below average compared to their peers. Their poor visuospatial, working memory skills reliably discriminate them from those with SLI.[120] Rooijen and colleagues found non-verbal intelligence and working memory were associated with the growth rate of arithmetic performance from 7–9 years of age, highlighting the importance of non-verbal intelligence and working memory to the development of arithmetic performance of children with cerebral palsy.[121]

Specific Learning Disorder (SLD)

Specific learning disorder combines the diagnoses of dyslexia or reading disorder, mathematics disorder, written expression disorder, and learning disorder not otherwise specified. Dyslexia is a specific learning disability characterized by unexpected difficulties in accurate and/or fluent word recognition, decoding, and spelling. Performance is comparable for both verbal and visuospatial, short-term memory tests: there are usually no signs of deficits in these measures. However, working memory scores show a different pattern. Specifically, there are verbal working-memory impairments, but relative strengths in visuospatial working memory. These verbal working memory deficits impact reading ability as reading requires considerable working memory "space" to keep all the relevant speech sounds and concepts in mind. This process can exceed the capacity of the dyslexic individual and ultimately result in

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Applied Cognitive Psychology 21 (2007): 473–87.

[120]Tracy Alloway and L. M. Archibald, "Working Memory and Learning in Children with Developmental Coordination Disorder and Specific Language Impairment," *Journal of Learning Disabilities* 41 (May-June 2008): 251–62.

[121]M. van Rooijen et al., "Cognitive Precursors of Arithmetic Development in Primary School Children with Cerebral Palsy," *Research in Developmental Disabilities* 35, no. 4 (April 2014): 826–32.

frustration when they encounter new vocabulary words or challenging texts.[122]

Dyscalculia, or mathematics disorder, is where students struggle to learn or understand mathematics. An estimated 5 to 8 percent of children are dyscalculic, with an equal representation of boys and girls affected. Students with dyscalculia find it difficult to decipher math symbols (e.g. +, -), understand counting principles ("two" stands for 2, for instance), and solve arithmetic problems. They also struggle with telling the time and recognizing patterns. Poor verbal working memory is usually only linked to dyscalculia in younger children,[123] and once they reach adolescence, verbal working memory is no longer significantly linked to mathematical skills.[124] Visuospatial, working-memory problems are linked to dyscalculia as it supports number representation, such as place value and alignment in columns in counting and arithmetic tasks.[125] Poor working memory is thought to be one explanation for dyscalculia, because it limits the ability to remember mathematical rules, from basic concepts like counting in ascending and descending order to more complicated algebraic functions.[126]

Interventions to Improve Working Memory

The review of NLDs show a deficit in working memory abilities for learners diagnosed with ADHD, specified learning disorders, motors disorders, communication

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[122]*Alloway Working Memory Assessment Manual,* 22.

[123]R. Gersten, N. C. Jordan, and J. R. Flojo, "Early Identification and Interventions for Students with Mathematics Difficulties," *Journal of Learning Disabilities* 38, no. 4 (July-August 2005): 293–304.

[124]M. Reuhkala, "Mathematical Skills in Ninth-Graders: Relationship with Visuo-Spatial Abilities and Working Memory," *Educational Psychology* 21, no. 4 (2001): 387–99.

[125]A. D'Amico and M. Guarnera, "Exploring Working Memory in Children with Low Arithmetical Achievement," *Learning and Individual Differences* 15 (2005): 189–202.

[126]Tracy Alloway and M.C. Passolunghi, "The Relations between Working Memory and Arithmetical Abilities: A Comparison between Italian and British Children," *Learning and Individual Differences* 21, no. 1 (February 2011): 133–37.

disorders, autism spectrum disorders, and intellectual disabilities. In response to this link between working memory and a multitude of deficits, there is immense interest and controversy in working memory training, as numerous research studies and scientific articles have demonstrated that working memory can be increased through direct intervention in either the clinical or classroom setting.[127] In "The Role of Individual Differences in Cognitive Training and Transfer," Jaeggi and colleagues state,

> Evidence is accumulating through some research that some WM interventions result in generalization effects that go beyond the training task, an effect that is termed "transfer." The most consistent transfer effects have been found on related, but not trained, WM tasks; such effects are commonly termed "near transfer." In addition to near- transfer effects, some evidence for far-transfer effects has also emerged—that is, generalization to domains that are considerably different from the training task such as executive control task, reading tasks, mathematical performance measurements, and measures of intelligence.[128]

However, other studies have failed to show far transfer, suggesting that generalization effects are elusive, inconclusive and controversial.[129] Furthermore, Jaeggi and colleagues note methodological flaws in the studies. For example, active control groups have not been included possibly producing a Hawthorne, or placebo, effect and few studies show long term transfer effects.[130] In addition, individual differences in ability, age, personality, etiology, time training, group versus one on one, quality of instruction, feedback, and the trainer's time are believed to impact the effectiveness of

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[127]Susanne M. Jaeggi et al., "The Role of Individual Differences in Cognitive Training and Transfer," *Memory and Cognition* 42, no. 3 (April 2014) 464. See also P. Peng et al., "A Meta-Analysis of Mathematics and Working Memory: Moderating Effects of Working Memory Domain, Type of Mathematics Skill, and Sample Characteristics," *Journal of Educational Psychology* 108, no. 4 (May 2016): 455–73; C. C. von Bastian and K. Oberauer, "Distinct Transfer Effects of Training Different Facets of Working Memory Capacity," *Journal of Memory and Language* 69 (2013): 36–58.

[128]Jaeggi et al., "The Role of Individual Differences in Cognitive Training and Transfer," 464–65.

[129]Ibid., 465.

[130]The Hawthorne effect refers to the assumption that people will adjust their behavior in accordance to their perceived expectations.

the training.[131] In a meta-analysis on the benefits of computer-based working memory training, Melby-Lervag and Hulme conclude,

> The programs produced reliable short-term improvements in working memory skills. For verbal working memory, these near-transfer effects were not sustained at follow-up, whereas for visual spatial working memory, limited evidence suggested that such effects might be maintained. More importantly, there was no convincing evidence of the generalization of working memory training to other skills (nonverbal and verbal ability, inhibitory processes in attention, word decoding, and arithmetic).[132]

Computer Training Program to Increase Working Memory

Several computer-based working memory training programs have been developed since 2000. *Cogmed Working Memory Training* is used in over 30 countries in the clinic and classroom setting. It was originally developed to improve working memory in learners with ADHD.[133] Klingberg and associates showed an increase in working memory abilities for children with ADHD and adults without ADHD. The participants were measured by the Stroop test, working memory test, and the Raven's Progressive Matrix.[134] Since the initial study, numerous research studies have been completed showing improvements in working memory.[135] *Cogmed* recommends training for 30–45

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[131] Jaeggi et al., "The Role of Individual Differences in Cognitive Training and Transfer," 465.

[132]M. Melby-Lervag and C. Hulme, "Is Working Memory Training Effective? A Meta-Analytic Review," *Developmental Psychology* 49, no. 2 (2013): 270–91.

[133]Ibid., 272–73.

[134]T. Klingberg, "Training and Plasticity of Working Memory," *Trends in Cognitive Sciences* 14, no. 7 (2010): 317–24.

[135]J. Holmes and S. Gathercole, "Working Memory Deficits can be Overcome: Impacts of Training and Medication on Working Memory in Children with ADHD," *Applied Cognitive Psychology* 24 (2010): 827–36. See also J. M. Chein and A. B. Morrison, "Expanding the Mind's Workspace: Training and Transfer Effects with a Complex Working Memory Span Task," *Psychonomic Bulletin & Review* 17, no. 2 (2010): 193.

minutes a day for five weeks, according to Melby-Lervag and Hulme.[136]

Another computer-based, working-memory training program developed by Ross Alloway is Jungle Memory. The program reports to increase academic scores in children with ADHD and other learning disorders. The program targets children between seven to sixteen years of age with a commitment of eight weeks.[137] In a recent study by Alloway, Bibile, and Lau, three groups were tested on measures of working memory, verbal and nonverbal ability, and academic attainment before training; also, the groups were re-tested on the same measures after training, as well as eight months later. The data indicate gains in both verbal and visuospatial, working-memory tasks for the high-frequency training group. Improvements were also evidenced in tests of verbal and nonverbal ability tests, as well as spelling, in the high-frequency training group.[138]

Cognitive Development Programs Using Human Mediators

An approach missing from the reviews on working memory and cognitive skill training are programs that do not utilize a computer-based program but a human mediator. Within those studies using computer-based programs, the cognitive enhancement of learners with severe NLD receives inadequate attention.[139]

Bright Start

Research on the impact of cognitive development programs of children with

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[136]Melby-Lervag and Hulme, "Is Working Memory Training Effective?," 270.

[137]T. P. Alloway, "Can Interactive Working Memory Training Improving Learning?" *Journal of Interactive Learning Research* 23, no. 3 (2012): 197–207.

[138]T. P. Alloway, V. Bibile and G. Lau, "Computerized Working Memory Training: Can it Lead to Gains in Cognitive Skills in Students?" *Computers & Human Behavior* 29 (2013): 632–38.

[139]Alex Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities: A Multicenter Study using Feuerstein's Instrumental Enrichment-Basic Program," *Research in Developmental Disabilities* 31 (2010): 551–59.

developmental disabilities, such as Down syndrome and other genetic syndromes, intellectual disabilities, and cerebral palsy is limited.[140] Yet the research that has been done substantiates that learners with intellectual disorders can participate and benefit from cognitive development and enrichment programs. The "Bright Start" program of Brooks and Haywood, which is based on Feuerstein's theories, increases intelligence quotient (IQ), enhances logical reasoning and problem-solving skills, allows children to be included in the regular classroom, and increases academic performance and intrinsic motivation.[141] Klauer's inductive reasoning program and Paour's "transformation box" program have demonstrated the ability of learners with intellectual disorders to move beyond the pre-operational level of thinking.[142]

Philosophy for Children Program

Haywood comes from a psychological perspective, whereas the next program, which seeks to enhance children's cognitive functioning, comes from a philosopher, Matthew Lipman. His Philosophy for Children program examines the classroom community of inquiry and the use of story texts to stimulate thinking. Like Feuerstein, Lipman places a significant role on the adult mediator to enable children to reach higher levels of cognitive abilities.[143] His program is a meditational tool in which the aim is "not to turn children into philosophers or decision-makers, but to help them become more

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[140]Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[141]H. Carl Haywood, "Thinking in, around, and about the Curriculum: The Role of Cognitive Education," *International Journal of Disability, Development, and Education* 51, no. 3 (September 2004): 244.

[142]K. J. Klauer, "A New Generation of Cognitive Training for Children: A European Perspective," in *Learning Potential Assessment and Cognitive Training,* ed. G. M. van der Aalsvoort, W. Resing, and A. Ruijssenaars (New York: Elsevier Science, 2002), 147–74; J. L. Paour, "Induction of Logic Structures in the Mentally Retarded," in *Interactive Assessment,* ed. C. Haywood and D. Tzuriel (New York: Springer, 1993), 119–66.

[143]Lena Green, "Cognitive Modifiability in South African Classrooms," in *Cognitive Modifiability in Learning,* 142.

thoughtful, more reflective, more considerate, more reasonable individuals."[144]

Reuven Feuerstein: Pioneer of Neuroplasticity

The first program to increase intellectual performance with learners with neurodevelopmental learning disorders was developed more than fifty years ago by Reuven Feuerstein, clinical and cognitive psychologist who believed that intelligence was changeable and modifiable regardless of age, genetics, neurodevelopmental conditions, and developmental disabilities.[145] Feuerstein worked with a wide range of different groups of people—from Holocaust survivors to people who had suffered from brain damage, Down syndrome, and autism, to those who are intellectually gifted. When he began working with the children who had survived the Holocaust, the goal was to rehabilitate them from their traumatic experiences. He asked himself, "How will I be able to speak to them tomorrow morning about what they had learned, or about Bible chapters, or about any other study subject? The question that bothered me most of all was: Were these children capable of change after all they had been through?"[146]

"Belief in modifiability" is an essential element of Feuerstein's Theory of Structural Cognitive Modifiability.[147] According to Kozulin, who is the academic coordinator of the international department at the Feuerstein Institute, Feuerstein was often criticized for deliberately including a "belief system" into his theory, because according to the critics there is no place for "beliefs" in scientifically based programs.[148] In *Changing Minds and Brains*, Feuerstein states, "I have come to believe that spiritual

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[144]Matthew Lipman, Ann Margaret Sharp, and Frederick Oscanyan, *Philosophy in the Classroom* (Philadelphia: Temple University Press, 1980), 69–70.

[145]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 8–9.

[146]Ibid., preface, xvii.

[147]Ibid., 6.

[148]Alex Kozulin, e-mail to the author, August 20, 2015.

thinking and behavior produces changes in the gray matter of the brain."[149] Christian educators agree that our faith consists of belief and trust, and also impacts who we are.[150]

Reuven Feuerstein was born in the village of Botosani, Romania, in 1921. He was raised in a devout orthodox Jewish family, as previously mentioned; he studied the Bible throughout his life, and credited the daily discussions of Scripture with his father with developing his cognitive abilities.[151] To reiterate his theistic worldview, he stated, "The individual is asked to act in the image of [God] as is stated: [God] made man in his image."[152]

Feuerstein studied at the University of Geneva, completing degrees in general and clinical psychology (1952) and obtained a license in psychology (1954). In 1970 he earned his Ph.D. in developmental psychology at the Sorbonne where his major areas of study were developmental, clinical, and cognitive psychology from a cross-cultural perspective. He served as professor of educational psychology in Bar Ilan University school of education (Israel), and as an adjunct professor at Vanderbilt University's Peabody college of education. He was the chairman of the International Center for the Enhancement of Learning Potential (ICELP) in Jerusalem until his death in 2014. The primary focus of the ICELP and his life's work has been the development of the theories of structural cognitive modifiability (SCM), mediated learning experience (MLE), the Learning Propensity Assessment Device (LPAD), which is a dynamic assessment, and the Instrumental Enrichment [IE] basic and standard programs, an active intervention to modify cognitive structures.

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[149]Feuerstein, Falik, and Feuerstein, *Changing Minds and Brains*, 123.

[150]Jonathan H. Kim, "Intellectual Development and Christian Formation," in *Christian Formation: Integrating Theology and Human Development,* ed. James R. Estep and Jonathan H. Kim (Nashville: B and H Publishing Group, 2011), 80.

[151]Reuven Feuerstein and Ann Lewin-Benham, *What Learning Looks Like: Mediated Learning in Theory and Practice, K-6* (New York: Teachers College Press, 2012), 5–6.

[152]Shmuel Feuerstein, *Biblical and Talmudic Antecedents,* 5.

Intelligence is Modifiable

Since the 1950s, Feuerstein has been a critic of the standard views of intelligence. He had observed the modifiability of the brain through the application of MLE. However, fewer than forty years ago, when he addressed the Association for Supervision and Curriculum Development's national convention in the United States, some walked out when he stated, "Intelligence is modifiable."[153] Today the discoveries in neuroscience confirm and support Feuerstein's theory known as Structural Cognitive Modifiability (SCM) that presents an optimistic view of the learner and one's propensity to be modified.

Intelligence is Teachable

Another critic of standard views of intelligence is Robert Sternberg, an American psychologist and professor of human development at Cornell University. He is an advocate of understanding and teaching intelligence. He defines successful intelligence as "the integrated set of abilities needed to attain success in life, however an individual defines it, within that individual's sociocultural context. Successfully intelligent people adapt to, shape, and select environments."[154] After studying various approaches on training intelligence, Sternberg presented his Triarchic Theory of Intelligence. There are three abilities that compose successful intelligence: analytical ability, creative ability, and practical ability. Sternberg explains, "Analytical ability is used when a person analyzes, evaluates, compares, or contrasts. Creative ability is used when a person creates, invents, or discovers. Practical ability is used when a person puts into practice, applies, or uses what he or she has learned."[155] Sternberg believes that

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[153]James Bellanca, foreword to *What Learning Looks Like,* xi.

[154]Robert Sternberg and Elena L. Grigorenko, *Teaching for Successful Intelligence: To Increase Student Learning and Achievement* (Thousand Oaks, CA: Corwin Press, 2007), 4.

[155]Ibid., 10.

intelligence is fluid and can change as the brain adapts. Successful intelligence is the kind of intelligence used to achieve important goals. People who succeed, whether by their own standards or by the standards of others, are those who have managed to acquire, develop, and apply a full range of intellectual skills, rather than merely relying on the inert intelligence that schools so value. These individuals may or may not succeed in conventional testing, but they have something in common that is much more important than high test scores. They know their strengths; they know their weaknesses. They capitalize on their strengths; they compensate for, or correct their weaknesses. In doing so, they go beyond the conventional definition of intelligence, according to Sternberg.[156]

Multiple Intelligences

Howard Gardner, a colleague of Sternberg and Feuerstein, is world renowned for his theory of multiple intelligences.[157] In discussing an intelligence, he states, "The possession of an intelligence is most accurately thought of as a potential; an individual in possession of an intelligence can be said to have no circumstance that prevents him from using that intelligence."[158] He identified eight different areas of intelligences: verbal-linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, naturalistic, and interpersonal. From 1994–1995 Gardner explored the relation between intelligences in more depth:

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[156]Sternberg and Grigorenko, *Teaching for Successful Intelligence*, 10–12.

[157]While many educators have embraced Gardner's theory, there are numerous critics in the field of neuroscience, psychology, and psychometrics; these cite the absence of empirical research to prove Gardner's theory. For one such critic, see Jamon F. Peariso, "Multiple Intelligences or Multiply Misleading: The Critic's View of the Multiple Intelligences Theory" (Spring 2008), accessed October 6, 2016, ED 500515, ERIC. See also James Traub, *Better by Design? A Consumer's Guide to Schoolwide Reform* (Washington DC: Thomas B. Fordham Foundation, December 1999), accessed October 6, 2016, ED437423, ERIC; John White, "Howard Gardner: The Myth of Multiple Intelligences" (lecture, meeting of the Institute of Education, University of London, November 17, 2004), accessed October 6, 2016, http://eprints.ioe.ac.uk/1263/1/WhiteJ2005HowardGardner1.pdf; Daniel T. Willingham, "Reframing the Mind," Check the Facts, *Education Next*, Summer 2004, accessed October 6, 2016, http://education next.org/files/ednext20043_18.pdf.

[158]Howard Gardner, *Frames of the Mind: The Theory of Multiple Intelligences* (New York: Basic Books, 2011), 73.

> While intelligences may possess the same names as cultural activities, they are not the same thing: as one example, the performance of music entails several intelligences (among them bodily and interpersonal); as another example, individuals strong in spatial intelligences can pursue a range of careers and avocations (running the gamut from sculpture to surgery). What we know and how we parse the world may well be in part a reflection of the intelligences with which our species has been endowed.[159]

Gardner suggested three applications of "intelligence." First, everyone possesses one of the eight intelligences. Second, the dimension of intelligences is unique as each learner is unique. Third, the manifestation and application of one's intelligences is influenced by his or her goals.[160]

Cognitive Functions

While Sternberg and Gardner explore the complexity of different types of intelligence, Reuven Feuerstein examines the cognitive function underlying intelligence and what is going on in the learner's mind. Feuerstein defines cognitive functions as "thinking abilities" that can be taught, learned, and developed.[161] Feuerstein has categorized the cognitive functions according to the three major phases of the mental act: input, elaboration, and output. Although artificially separated into three phases, cognitive functions don't necessarily occur separately in life. However, the subdivision is useful to analyze and describe thinking as well as to determine what factors might negatively affect thinking.[162] Teachers and parents can use this model to better understand and help the learner who is experiencing difficulties with a particular task. By having a working knowledge of the cognitive functions, teachers[163] can differentiate between errors due to

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[159]Gardner, introduction to *Frames of the Mind*, xvi.

[160]Ibid., xv.

[161]Reuven Feuerstein et al., *The Feuerstein Instrumental Enrichment Program (*Jerusalem: ICELP Publications, 2006), 135.

[162]Feuerstein et al., *Feuerstein Instrumental Enrichment Program*, 135.

[163]Feuerstein, Falik, and Feuerstein, *Changing Minds and Brains*, 5. Reuven Feuerstein and his co-authors state, "All teaching is not mediation; but all mediation is teaching."

a lack of knowledge or from a deficient cognitive function.[164] For example, if the learner fails in the task of classification, it is not enough to comment on the learner's poor intelligence or inability to classify, but rather the underlying causes of the difficulty (which can be found in one of the three phases of thinking) should be sought. The inability to classify, for instance, may be due to underlying underdeveloped functions, such as imprecise data gathering at the input phase or poor communication skills at the output phase. A detailed analysis of a learner's cognitive functions requires an in-depth understanding of the three phases of the mental act.[165]

Deficient Cognitive Functions and Corrections Needed: Input Level

The following list identifies and describes the deficient cognitive functions that Feuerstein's Instrumental Enrichment (FIE) seeks to correct in learners with neurodevelopmental learning disorders and learning disabilities. Understanding the degree to which the learner is affected directs the mediation process for cognitive modifiability.[166]

1. Blurred and sweeping perception of essential information occurs. The learner struggles to gather the correct information. Correction: The learner learns to focus and perceive the data through his senses.

2. Difficulty in temporal and spatial orientation occurs. The learner lacks the ability to organize information realistically and to describe events in terms of where and when they occur. Correction: The learner learns the critical concepts of right, left, front, and back to know where they are positioned in space.

3. Deficient skills in precision and accuracy are present. Correction: The learner collects the correct information.

4. Inability to identify an object when there is a change in size, shape, quantity, or

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[164]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 131–33.

[165]Mandia Mentis et al., *Bridging Learning: Unlocking Cognitive Potential In and Out of the Classroom* (Thousand Oaks, CA: Corwin, 2009), 115.

[166]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 136.

orientation, though it is the same object. Correction: The learner is able to decide what characteristics stay the same even when change happens.

5. Lack of capacity for considering two or more sources of information at once is present. This is reflected in dealing with data in a piecemeal fashion rather than as a unit of organized facts. Correction: The learner's able to keep two ideas in his mind at the same time and compare them.

6. Impulsive and unplanned exploratory behavior is present. Correction: The learner is able to systematically approach new information and objects.[167]

Deficient Cognitive Functions and Corrections Needed: **Elaboration Level**

1. Lack of ability to recognize the existence and definition of an actual problem. Correction: The learner can define the problem.

2. Inability to select relevant vs. non-relevant cues or data in defining a problem is present. Correction: The learner can recognize what is relevant to the problem and what can be ignored.

3. Difficulty in comparative behavior is present. This may be due to slow processing and inability to make comparisons between two or more things. Correction: The learner can see the similarities and differences between two things.

4. A narrow mental field is present. There is an inability to combine, group, and coordinate information. Correction: The learner can recall and use several pieces of information.

5. The projection of virtual relationships is impaired. The ability to perceive the relationship between events is difficult. Correction: The learner can understand relationships, apply conceptual labels, and categorize objects. He understands the main idea.

6. The absence of or need for logical evidence, inferential-hypothetical thinking, and hypothesis development occurs. Correction: The learner is able to use hypothetical thinking to test a hypothesis. He can see cause-and-effect relationships and use logical evidence.

7. Inability to visualize and create mental images is present. Correction: The learner is able to move away from concrete thinking to visualization.

8. Difficulty defining goals, planning behavior, and taking steps in problem solving occurs. Correction: The learner is able to form problem-solving strategies, make a

[167]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 140–53.

plan, state the steps, and provide the reasons.[168]

Deficient Cognitive Functions and Corrections Needed: **Output Level**

1. Egocentric communicational modalities are present. It is difficult for the learner to relate to others and to see things from another's perspective. Correction: The learner is able to consider another person's point of view.

2. Lack of ability to repeat an attempt after a failure or blocking is present. Correction: The learner is able to persevere and overcome blocking.

3. Difficulty in projecting virtual relationships. Correction: The student is able to see virtual relationships such as two women can be cousins or four dots can be a square.

4. Use of trial-and-error responses, which leads to failure to learn from previous attempts, is present. Correction: The learner is able to stop and think through a plan of action.

5. Lack of, or impaired tools for communicating adequately elaborated responses. Correction: The students is able to give a thoughtful response.

6. Lack of, or impaired, need for precision and accuracy in communicating one's responses. Correction: The student is able to be precise and accurate when communicating.

7. Lack of self-control, impulsive, or acting-out behavior is demonstrated. Correction: The student exhibits self-control in speech and behavior.

8. Unable to visually transport information from one place to another, or unable to see the missing part. Correction: The learner is able to see the relationship between things that are not present.[169]

Feuerstein has sought to identify and correct these deficits to enable students to reach their full cognitive potential, as well as to increase their internal motivation and personal confidence. By using mediation, these deficient functions can be corrected, formed and modified in significant ways.[170]

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[168]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 153–76.

[169]Ibid., 178–83.

[170]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 83–84.

Dynamic Assessments

Feuerstein developed a complex set of dynamic assessment techniques, which are used to identify the gaps in human cognitive development. The Learning Propensity Assessment Devise (LPAD) is a battery of instruments that evaluates the way an individual learns and identifies the development of cognitive functions. The LPAD allows educators and psychologists to observe and record how a person learns. This reveals what kind of teaching is required to respond more successfully, as well as the amount of observed learning that is retained when new and more difficult tasks are presented. The assessment provides a picture of an individual's cognitive modifiability and learning potential.[171]

The LPAD differs from traditional educational and psychological evaluations in four ways: (1) the assessment tools; (2) the assessment situations; (3) the emphasis of a process rather than a product orientation; (4) the interpretation of the outcome of the assessment. See below.

1. *Assessment tools differences*. The traditional assessments are static and focus on what the student knows rather than what they can know. Static tests do not allow learning to take place. Dynamic assessment allows learning and thinking to occur. The focus is on the learning process. "We are not concerned with informational questions that the learner might know. Such questions do not offer the opportunity to modify one's ability to deal with new situations," according to Feuerstein, Feuerstein, and Falik.[172]
2. *Assessment situation differences*. The traditional test assessor looks at what is fixed, permanent, and unchanging in the student. The environment must be void of variations for different students. The situation must be repeated in different places with different students and different assessors. The dynamic assessment does not standardize the environment. While there are consistent guidelines when diagnosing, the student is compared only to himself. "In dynamic assessment, assessors will do everything in their power to create in the examinee the experience of modifiability," the authors said.[173]

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[171]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 85.

[172]Ibid., 90.

[173]Ibid., 91.

3. *Emphasis of a process rather than a product orientation*. The dynamic assessment looks at the cognitive functions of the input, elaboration, and output phases. The process the student utilizes is the focus. A static assessment focuses on the answer, or product. The student's success is based on his ability to give the correct response in the allotted time. The dynamic assessor asks, "What is the process through which the examinee can be modified? How can we bring about change in him or her?"[174]
4. *The interpretation of the outcomes of the assessment*. Static assessment utilizes quantitative terms using norms which consider the number of correct and incorrect answers. The dynamic assessment does not consider percentiles and standard scores. "The goal of the assessment is to uncover the individual's learning potential and to address ways in which learning can be facilitated to manifest real learning potential," according to Feuerstein, Feuerstein, and Falik.[175]

Cognitive Abilities Profile

As psychologists and educators saw the benefit of a dynamic assessment, the initial work on the Cognitive Abilities Profile (CAP) began in 2002. It was developed by a group of educational psychologists in the United Kingdom to introduce the concepts and methods of dynamic assessment.[176] The CAP is based on the tripartite learning model which has three elements, including the student, the mediator, and the task. According to Tan and Seng, "When the task, teacher, and learner are all of equal significance and are equally subject to intervention and analysis, the risk of making judgments about the abilities of the learner based on partial information is avoided."[177] The CAP aimed to measure the cognitive changes in the learner and focused on the learner's cognitive strengths and difficulties, measured the learner's response to teaching strategies, and used the mediating adult or teacher as the key agent to bring about cognitive change in the student.[178] However, the assessment was not without challenges. There was insufficient

[174]Feuerstein, Feuerstein, and Falik, *Beyond Smarter,* 92–93.

[175]Ibid., 93.

[176]Tan and Seng, *Cognitive Modifiability in Learning,* 175.

[177]Ibid., 178–79.

[178]Ibid., 175–80.

time to assess cognitive strengths and deficiencies; in addition, a high level of training and experience was required, and the interpretation of the assessment with classroom implications was difficult.[179]

As technology has changed, educators must adapt to focus on the thinking process and problem, not product and content. Tan and Seng state, "These processes can empower the learner to become independent, flexible, and adaptable in order to meet the challenges of change. These processes not only impact curriculum skills, but also lifelong learning related to social, work, and community environments."[180]

Instrumental Enrichment

Moving from dynamic assessments to cognitive intervention programs, which focus on the thinking process, the importance of the mediator, as well as cognitive modifiability, is crucial. The theory of SCM and the applications of MLE are the foundation of Feuerstein's Instrumental Enrichment (FIE) standard and basic programs that were developed over forty years ago. FIE Standard is a cognitive development program emphasizing critical thinking strategies. The FIE Standard program contains fourteen instruments designed to build the perquisites and processes of learning rather than academic content or skills. The FIE Basic program has been designed for learners 3–8 years of age who have learning challenges. FIE Basic complements the FIE Standard version and has eleven instruments. They can be implemented in a classroom or as a therapeutic intervention in a small group or an individualized basis. FIE initially focused on culturally deprived and low-functioning children and adolescents with chromosomally-determined conditions to build their cognitive functions and structures. The program has expanded to include learners of all ages and abilities to strengthen their

[179]Tan and Seng, *Cognitive Modifiability in Learning*, 175–76.

[180]Ibid., 205–06.

learning capacity.[181]

Research Studies on Cognitive Enhancement

The Feuerstein Institute has conducted research that confirms cognitive abilities can be modified.[182] Instrumental Enrichment (FIE) and MLE have been found to enhance cognitive abilities of learners with neurodevelopmental learning disorders.[183] Many of these learners also have cultural deprivation and differences. These studies have encompassed many types of student populations using FIE.[184] Studies in the following areas are discussed, including attention deficit disorders, autism, and developmental disabilities.

Attention Deficit Disorders

In regard to learners with attention deficit disorder (ADD), Krieger and Kaplan found a significant increase in reading accuracy and comprehension.[185] Roth and Szamoskozi found students with ADHD increase their precision, their written expression of ideas on paper, their ability to find relevant cues in problem-solving situations, and their declarative knowledge.[186]

Autism

Research in the field of autism continues to develop. The research staff at

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[181]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 1–2.

[182]Tan and Seng, *Cognitive Modifiability in Learning,* 4–9.

[183]Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[184]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 430–59.

[185]S. Kreiger and M. Kaplan, "Improving Inattention and Reading in Inattentive Children through MLE: A Pilot Study," *International Journal of Cognitive Education and Learning* 1, no. 3 (1990): 185–92.

[186]M. Roth and S. Szamoskozi, "Activating Cognitive Functions of Children Living in an Impoverished Environment: A Romanian Perspective" (Hampshire, England: Project Inside, 2001).

ICELP are reviewing all of the studies that use Feuerstein Instrumental Enrichment (FIE). A study in Canada with twenty autistic learners who used FIE indicates a high level of success using MLE, and the results were reported at several international conferences.[187] Gross and Stevens demonstrated improvements in visual attention and tracking, following directions, understanding cause and effect, turn taking, making choices, and predication and persistence.[188]

Specific Learning Disabilities

IE approaches were found to impact reading scores in sixth grade students who were reading two years below grade level in remedial classes in Westchester County, New York.[189] In a three year study with students who had deficient language skills a significant increase was found in oral and written language, vocabulary, and grammar.[190]

Neurodevelopmental Disabilities

Kozulin and colleagues conducted a study with 104 learners from Canada, Belgium, Italy, and Israel who had neurodevelopmental disabilities, cerebral palsy, genetically-based intellectual impairments, autism or ADHD. The FIE Basic program that is designed for young learners was used over thirty to forty-five weeks. The intervention emphasizes systematic perception, self-regulation, conceptual vocabulary, planning, decoding emotions, and social relationships. These are then transferred to principles in daily life. The research subjects showed statistically significant improvements in the

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[187]David S. Martin, "Paradigm Assessment and Treatment Program for Children with Autistic Features," *ICELP News* 1, no. 1 (January 2001): 12, accessed June 20, 2015, http://ictaweb.org/51-2/.

[188]S. Gross and T. Stevens, "Mediation and Assessment of a Young and Low Functioning Child: An Initial Session," in *Enhancing Cognitive Functions,* ed. O. Tan and A. Seng (Singapore: McGraw Hill, 2005), 189–208.

[189]S. Brainin, "The Effects of Instrumental Enrichment on the Reasoning Abilities, Reading Achievement, and Task Orientation of 6th grade Underachievers" (PhD diss., Columbia University, 1982).

[190]P. Sanches, "The Study of Instrumental Enrichment as a Tool for Improving Language Proficiency," *Teaching Thinking and Problem Solving* 13, no. 3 (1994): 9–16.

WISC-R subtests of similarities, picture completion, and picture arrangement, as well as on Raven's Colored Matrices. [191]

In 2014, Krisztina Bohács studied learners from two to fourteen years of age with mild to moderate intellectual developmental disorders, including genetic syndromes, cerebral paresis, ADHD, and autism. The Raven Colored Matrices showed an increase in general intelligence, and there were significant changes in cognitive development. There was also growth in domains necessary for school readiness. Bohács states, "If applied systematically with children with intellectual disabilities for a longer period of time (maybe even for 3-4 years) the applied systems are expected to lead to increased learning effectiveness, more effective basic cognitive processes and thinking skills, and to prepare children for school learning and a better adaptation to the challenges of everyday life."[192]

Four-Year Case Study with *Equipping Minds Cognitive Development Curriculum*

Bohács recommended a three to four-year study with learners who have NLD. An individual case study was done with the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*)[193] from 2011-2015 with a learner with a NLD, namely Down syndrome.[194] In September 2011, Marie's[195] parents contacted Brown to discuss using *EMCDC* to strengthen Marie's cognitive abilities; visual and auditory processing speed,

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[191]Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[192]Krisztina Bohács, "Clinical Applications of the Modifiability Mode: Feuerstein's Mediated Learning Experience and the Instrumental Enrichment Program" (PhD diss., University of Szeged, Hungary, 2014), 18.

[193]Brown developed *EMCDC*, which includes a teacher workbook, student workbook, and instructional DVDs; it is intended for use in regular or special education classrooms, churches, or home environments by teachers, therapists, and parents.

[194]Carol T. Brown, "Equipping Minds for Christian Education: Learning from Neuroscience for Christian Educators," *Christian Education Journal* 13, no. 1 (2016): 147–68.

[195]The student's name has been changed to protect her privacy.

comprehension, working memory**,** long term memory, and reasoning skills.[196] According to her parents, despite all the support from Marie's teachers, occupational therapist, speech therapist, special education teacher, and principal in third grade, her Measures of Academic Progress (MAP) scores—yearly academic tests that measure student growth from semester to semester—stayed stagnant for a full year. In the fall semester of her fourth grade year the first MAP scores again showed no growth. Brown reviewed the academic and psychological testing showing an intellectual disability with deficits in processing, working memory, comprehension, and perceptual reasoning; she then agreed to begin working with Marie using *EMCDC*.

With the support of the school system, Brown worked with Marie an hour of every school day for the next twelve weeks. At the end of nine weeks, the principal enthusiastically reported that Marie had increased 20 points in reading, 11 points in math, 25 points in science, and 17 points in language arts. These gains were unprecedented, as students typically increase 3–5 points.

Until this time, Marie had made minimal progress and her academic test scores had remained static from third to fourth grade. The change in these scores had been achieved over the nine-week period through one-on-one cognitive developmental exercises for enhancing processing, working memory, comprehension, and reasoning; this was divorced from academic content. Previously, she had received the standard interventions, which included remediation of content, learning strategies, and accommodations. These may have short-term benefits, but were not targeting the underlying cognitive deficits in processing and working memory, which would increase her cognitive abilities.

Marie's progress is significant for those who still believe that measureable

[196]For privacy, the name used in the case study is a pseudonym.

intelligence is due primarily to nature or one's genetic factors, and only minimally due to nurture or environmental factors which holds to a limited potential for change.[197] Since Marie has an intellectual disability and Down syndrome, many educators believe these disorders limit her ability for significant academic gains.[198] However, Marie's improvement implies that cognitive developmental exercises do have far transfer effects to academic achievement for learners who have an intellectual developmental disorder. Below are the results of the MAP tests after that first nine weeks, and over the next four years. Figures 3, 4, 5, and 6[199] illustrate the MAP test results which demonstrate significant gains in academic abilities.[200] See figures below.

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[197]R. Herrnstein and C. Murray, *The Bell Curve: Intelligence and Class Structure in American Life* (New York: The Free Press, 1994), 22–23.

[198]Carolyn Mervis, interview by author, Louisville, KY, May 14, 2012. Mervis stated that in her research with students with Down Syndrome, she was not aware of any case where cognitive developmental exercises had generalized to academics in a nine-week period. Mervis performed a full cognitive assessment on Marie. She stated that the gains in processing and working memory were greater than she had ever seen; Carolyn Mervis, e-mail to the author, February 9, 2015. Marie and seven other students with Down Syndrome were asked to participate in a three-year pilot study with *EMCDC* with the University of Louisville Department of Psychological and Brain Sciences in the summer of 2011. The pilot study was not completed according to a correspondence with Mervin due to other research commitments within the department.

[199]Figures 3, 4, 5, and 6 are re-creations of the MAP test scores.

[200]It should be noted that while Marie has Down syndrome, the only accommodations she received on MAP testing was extended time and having a reader for math, science, and language. She read the reading assessments herself.

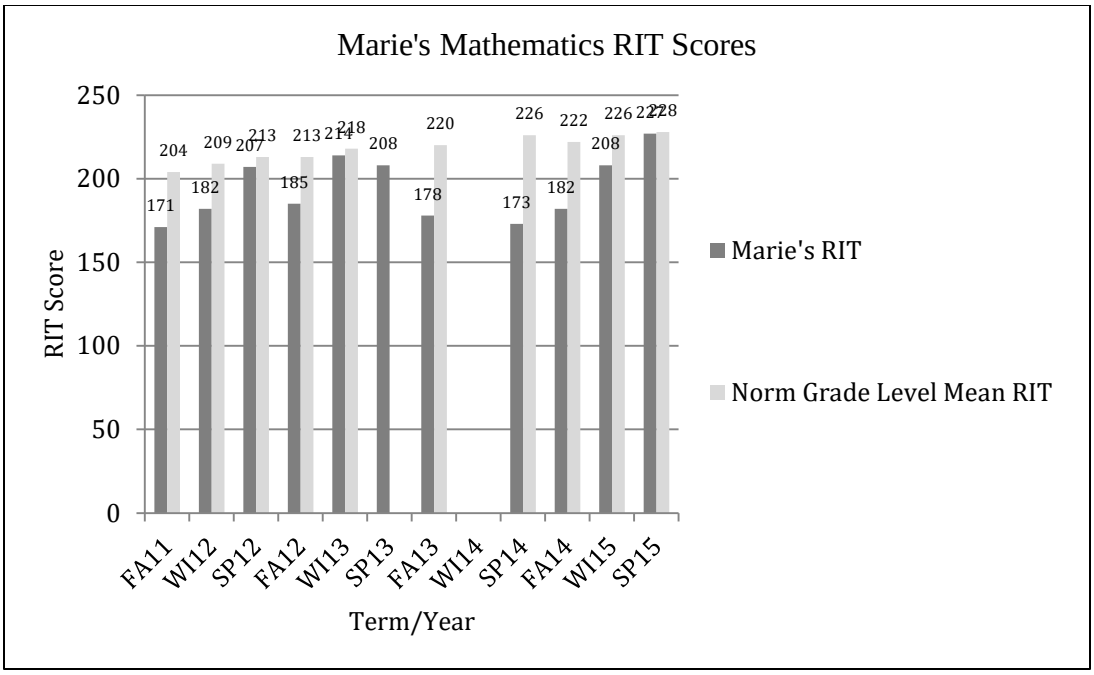

Figure 3. Marie's mathematics RIT scores

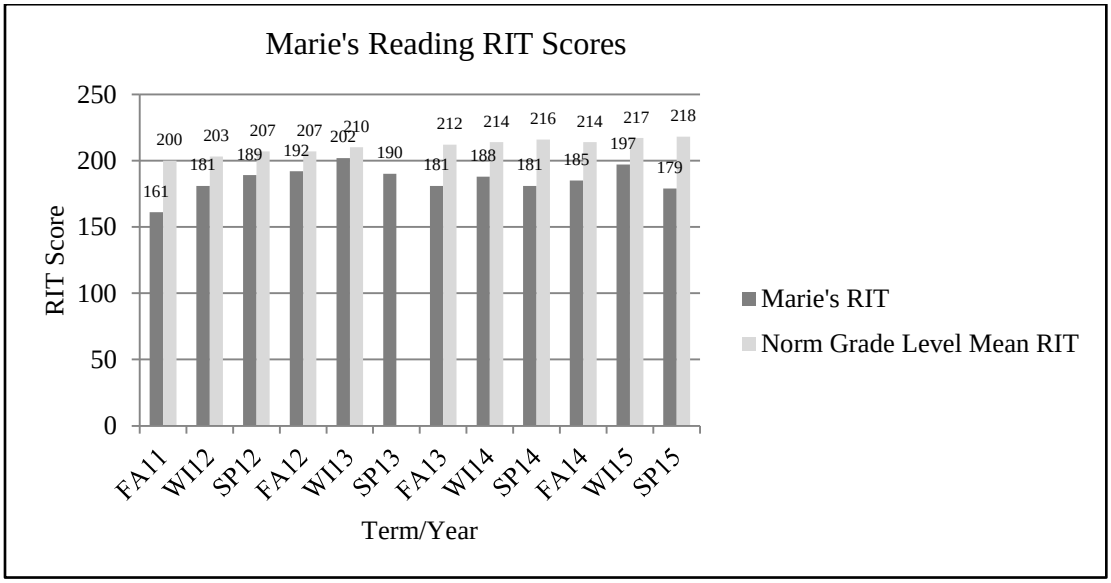

Figure 4. Marie's reading RIT scores

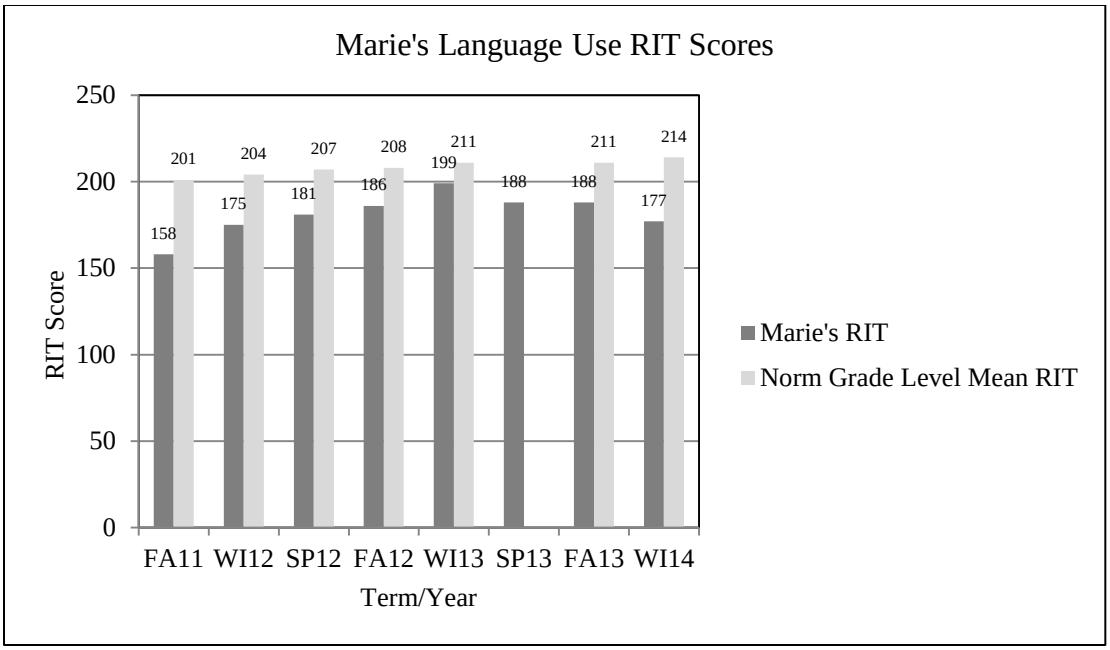

Figure 5. Marie's language RIT scores

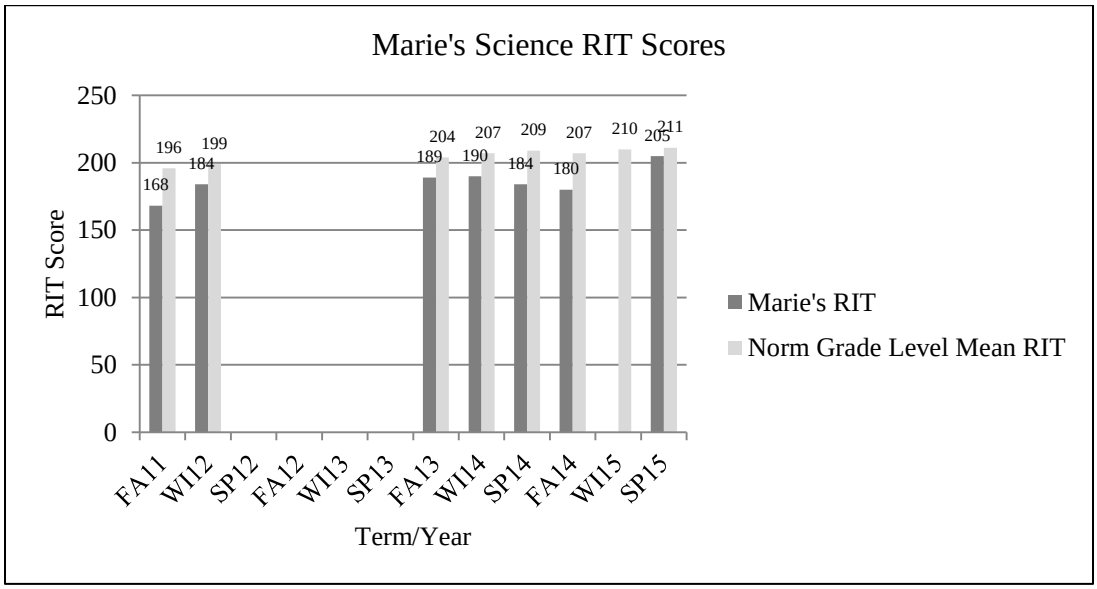

Figure 6. Marie's science RIT scores

Marie would continue the cognitive developmental exercises and continue to progress academically for the next four years. Her Kentucky Performance Rating for

Educational (KPREP) scores are illustrated on figures 7, 8, and 9 showing gains in math, reading, and writing on-demand.[201] Marie's student growth percentile (SGP) in reading was 93 percent in sixth grade and 7 percent in seventh grade. Her SCP was 63 percent in math as a sixth grader and 93 percent in seventh grade. Figure 10 illustrates the SCP for sixth and seventh grade.[202] In 2015, as a seventh grader, she scored in the 39th percentile in mathematics, 36th percentile in science, and the 7th percentile in reading on the Stanford Ten National Assessment Ranking. Figure 11 illustrates the Stanford National Ranking.[203]

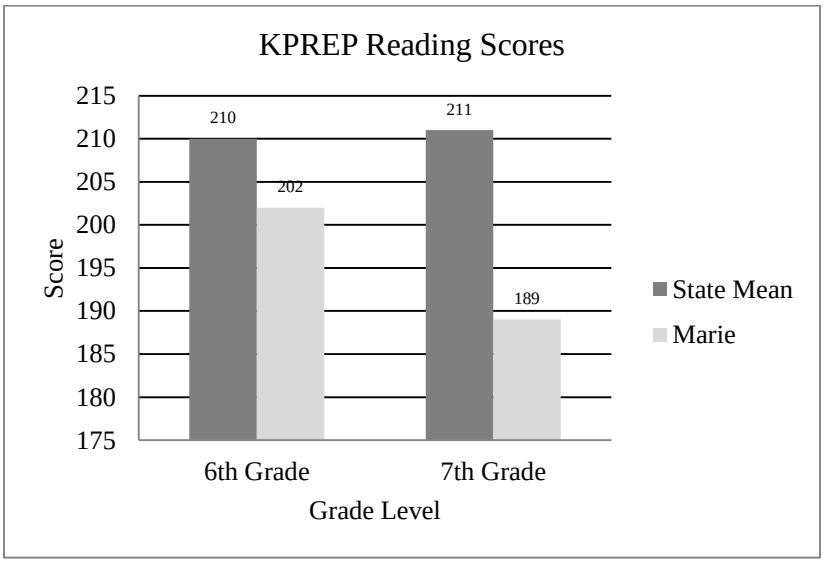

Figure 7. KPREP reading scores

[201]Figures 7, 8, and 9 are re-creations of the KPREP reading, math, and writing on-demand. Marie's Kentucky Performance Rating for Educational Progress (KPREP) scores in sixth grade showed strong growth. The KPREP test is more comprehensive and has historically been difficult for Marie. In seventh grade she scored two points above the state mean and was one point from a proficient status. The apprentice level for the seventh grade states that a student can compute a percent of a number, use ratios to solve problems, evaluate mathematical problems using order of operations with integers, solve two-step equations, evaluate algebraic expressions with two or more variables using order of operations, select and apply basic geometric formulas, identify cross sections of a 3-D object taken parallel to a base, identify an appropriate sample for a population, and compute measures of central tendency.

[202]Figure 10 is a re-creation of the SCP.

[203]Figure 11 is re-creation of the Stanford National Assessment Ranking.

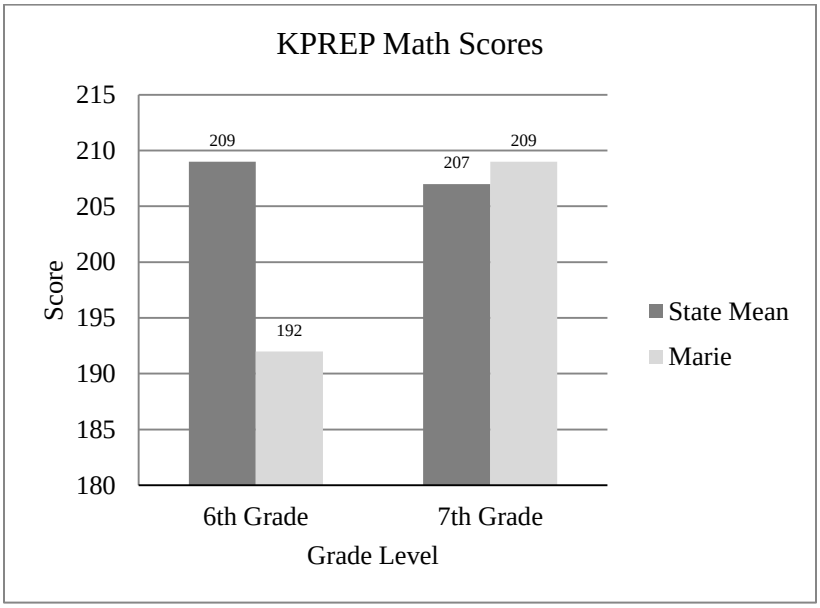

Figure 8. KPREP math scores

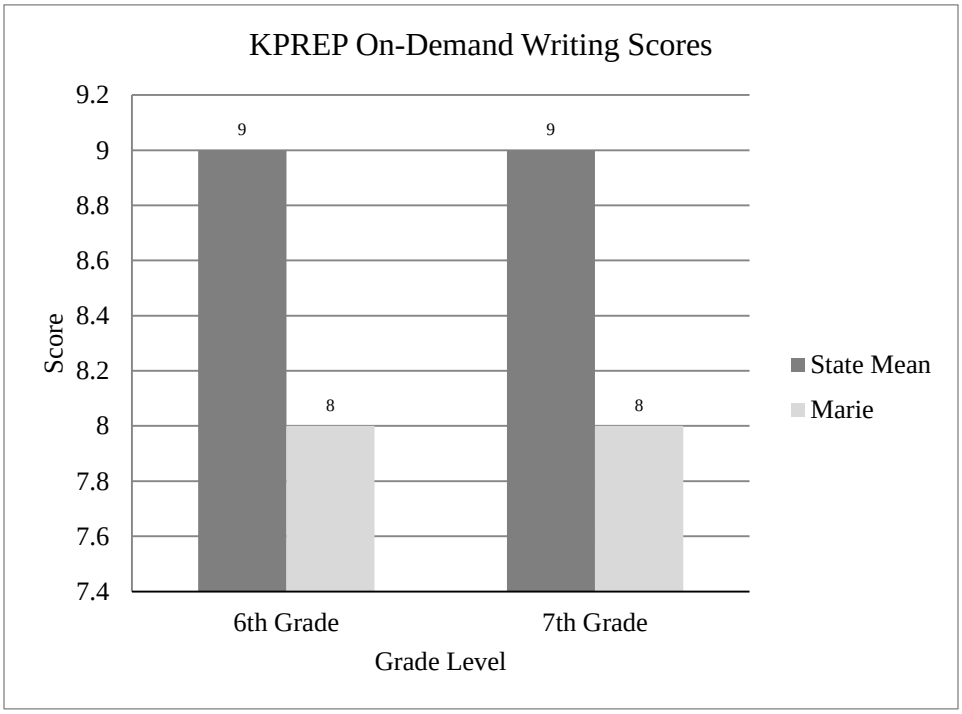

Figure 9. KPREP on-demand writing scores

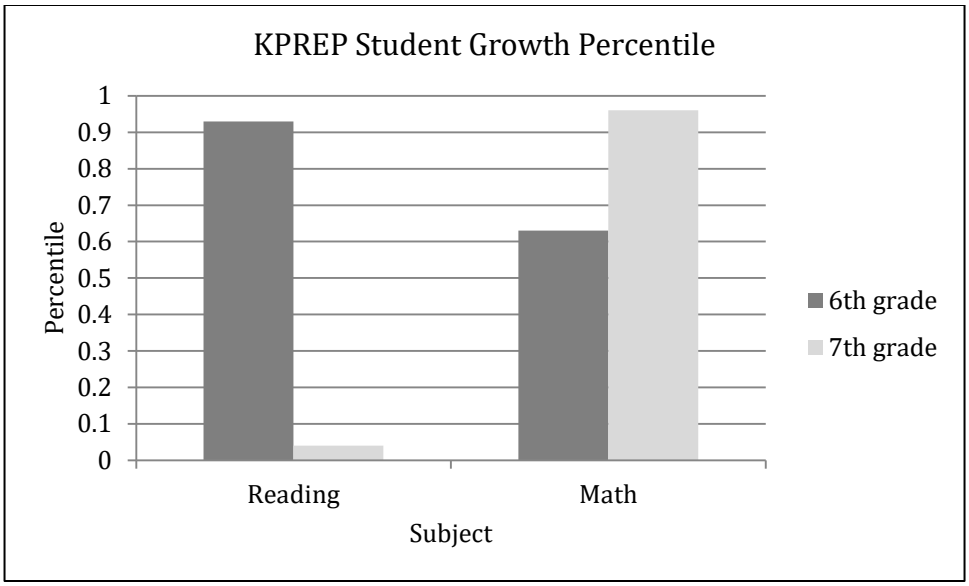

Figure 10. KPREP student growth percentile

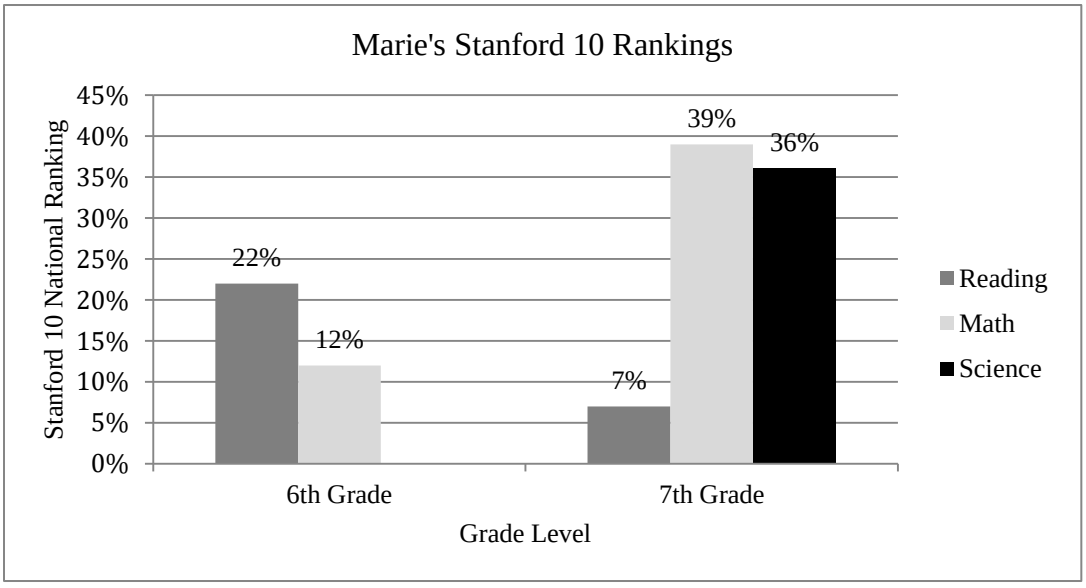

Figure 11. Marie's Stanford 10 rankings

Conclusion

The success of the research with Feuerstein's Instrumental Enrichment program based on the theory of SCM and implementation of MLE affirms that cognitive skills can be developed in the classroom or clinical setting through a human mediator.[204] However, in recent years the majority of research has utilized computer software programs to enhance cognitive skills with a focus on working memory training.[205] An approach missing from the reviews on working memory and cognitive skill training are programs that do not utilize a computer-based program but a human mediator. Within those studies using computer-based programs, the cognitive enhancement of learners with severe NLD receives inadequate attention.[206] In 2013, the journal of *Developmental Psychology* had an article evaluating the claims of computer-based cognitive skill programs by Hulme and Melby-Lervag who conducted a systematic meta-analysis review of the existing studies.[207] Hulme and Melby-Lervag concluded,

> Currently available working memory training programs have been investigated in a wide range of studies involving typically developing children, children with cognitive impairments (particularly ADHD), and healthy adults. Our meta-analyses show clearly that these training programs give only near-transfer effects, and there is no convincing evidence that even such near-transfer effects are durable. The absence of transfer to tasks that are unlike the training tasks shows that there is no evidence these programs are suitable as methods of treatment for children with developmental cognitive disorders or as ways of effecting general improvements in

[204]Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[205]Kenneth J. Kohutek, "The Children's Cognitive Enhancement Program: A Pilot Study," *Journal of Scholastic Inquiry: Education* 1 (October 2014): 166–67.

[206]Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities," 551–59.

[207]M. Melby-Lervag and C. Hulme, "Is Working Memory Training Effective? A Meta-Analytic Review," *Developmental Psychology* 49, no. 2 (2013): 270–91. See also H. L. Roediger and M. A. Pyc, "Inexpensive Techniques to Improve Education: Applying Cognitive Psychology to Enhance Educational Practice," *Journal of Applied Research in Memory and Cognition* 1 (2012): 242–48.

adults' or children's cognitive skills or scholastic attainments.[208]

The *Equipping Minds Cognitive Development Curriculum* (*EMCDC)* is a method of cognitive skill development based on the theory of Structural Cognitive Modifiability (SCM), Mediated Learning Experience (MLE), and a biblical worldview. Marie's results convinced Brown that further research with *EMCDC* was needed. Learners with NLD must have someone to mediate how to think, how to process information, and how to store information, in the same way that learners with special needs may need physical therapy to teach them how to roll over as infants or how to put one foot in front of the other to walk. The specific cognitive developmental exercises in *EMCDC* have strong implications for benefiting other learners with neurodevelopmental learning disorders. Cognitive developmental exercises could be incorporated into the teaching curriculum for every learner in the school, church, and home.[209] Strengthening cognitive abilities with the *EMCDC* has far transfer effects to academics as demonstrated in a four-year case study with Marie.

Most importantly, the biblical worldview of Comenius and theistic beliefs of Reuven and Shmuel Feuerstein affirm that all individuals, regardless of abilities should be treated with dignity because they are created in the image of God. Furthermore, through a human mediator each individual's cognitive capacities must and can be developed. For as Comenius stated, "We do not know to what uses divine providence has destined this or that man; but this is certain, that out of the poorest, the most abject, and the most obscure, He has produced instruments for His glory."[210]

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[208]Melby-Lervag, "Is Working Memory Training Effective?," 283.

[209]Marie's mother reported that Marie asked to meet with her pastor to discuss her personal relationship with Jesus Christ, made a profession of faith, and was baptized in a Southern Baptist Church on October 18, 2015. Brown was present at the baptism. Mother of case study subject, telephone conversation with the author, September 22, 2015.

[210]Melby-Lervag, "Is Working Memory Training Effective?," 66.

CHAPTER 3

METHODOLOGICAL DESIGN

This chapter describes the methodologies and procedures that were used in this research study. The purpose of this study was to examine the effect of the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*) on working memory in students diagnosed with specific learning disorder (SLD), a neurodevelopmental learning disorder, and whether an increase in working memory resulted in transfer effects within an educational setting, measured by standardized tests of academic attainment and non-verbal and verbal abilities. Additionally, this study explored differences with gender and age. Included in this chapter are explanations of the research questions, design overview, population, sample, delimitations, limitations of generalization, and instrumentation.

Research Question Synopsis

1. What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum*?
2. What, if any, are the effects of changes in working memory to academic abilities in learners using the *Equipping Minds Cognitive Development Curriculum*?
3. What, if any, is the effect of working memory on non-verbal and verbal abilities?
4. What, if any, is the effect of gender of the learner on working memory in students using the *Equipping Minds Cognitive Development Curriculum*?
5. What, if any, is the effect of the participant's age on working memory using the *Equipping Minds Cognitive Development Curriculum*?

Research Design Overview

This research design was a true quantitative experimental study of the effects on working memory when applying the *EMCDC* among learners diagnosed with specific learning disorder (SLD).[1] A school who serves learners with a specific learning disorder (SLD) initiated contact with Equipping Minds, which allowed access to the population sample. Equipping Minds communicated with school administrators in order to provide initial information about the study. A student participation consent form was sent to parents of prospective participants. Parental consent was obtained for each learner to participate in the study for 30 hours over a 7-week period. The school administrator randomly allocated the participants to either the active control or the training group.[2]

There was a training group who received the *EMCDC* in a small group for five days a week for 60 minute sessions for a minimum of 30 hours over 7 weeks from a mediator trained in *EMCDC*. In addition to the training group, there was an active control group that received academic support in a small group for five days a week for 60 minute sessions for a minimum of 30 hours over 7 weeks from a teacher. All participating learners continued to receive standard special educational support services as a result of their learning difficulties.

A working memory pre-test was completed using the *Automated Working Memory Assessment* 2nd ed. (*AWMA*-2). A nonverbal and verbal ability test was completed using the Kaufman Brief Intelligence Test (*KBIT* 2) by the learner. The learners completed the *EMCDC* cognitive skills training with a trained mediator using *EMCDC*. Following the completion of the cognitive development therapy, the learners

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[1]Paul D. Leedy and Jeanne Ellis Ormrod, *Practical Research: Planning and Design* (Upper Saddle River, NJ: Pearson, 2013), 234. Experimental designs offer a greater degree of control and, as a result, greater internal validity.

[2]The school administrators identified 32 students with a diagnosis of SLD, who had completed the *TerraNova* in 2015, and whose parents were supportive of their child's participation. Following these criteria, 14 males and 18 females in 4th-8th grade were identified. The school administrator then randomly placed them into the training or active control.

completed the working memory post-test using *AWMA*-2, the *TerraNova* academic assessment, and the *KBIT*-2 for verbal and non-verbal abilities.[3] The *AWMA*-2 is an online working memory assessment, and the scores were automatically calculated and interpreted on the computer software. The *KBIT*-2 was done with a qualified tester who was face-to-face with the participant. The *KBIT*-2 was scored manually according to the *KBIT*-2 testing manual. The *TerraNova* was administered by the school and submitted to the testing company who scored the test. The data was then compiled, evaluated, interpreted, and reported; in addition, a statistician analyzed the findings.[4]

Population

The population of this study consisted of learners with specific learning disorder (SLD). For the purpose of this study, qualification was determined by a diagnosis from a qualified professional who followed the eligibility criteria for determining the qualification for SLD. Each participant had completed the 2014-2015 *TerraNova*, a standardized academic assessment, prior to participating in the study.

Samples

This study included learners diagnosed with specific learning disorder (SLD) in a school who was familiar with *ECMDC* whose learners met the qualifications for participation. The school administrators randomly allocated the participants to either the active control or the training group. Thirty-two participants were obtained.

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[3]The *AWMA*, an online working memory assessment, *KBIT*-2, and academic assessment are standardized for children and adults.

[4]The school uses the *TerraNova,* 3rd ed. Survey to measure reading, mathematics, science, social studies, and language. It is an abbreviated version of the complete battery and provides a general measure of academic achievement. The school also uses the *TerraNova* CAT Plus to measure important skills in word analysis, vocabulary, language mechanics, spelling, mathematics computation.

Delimitations

This study had the following delimitations. First, the study was limited to a single school who was familiar with Equipping Minds for the research study. The school asked to be considered for the research study. The school has students in 1st–8th grade who have diagnosed learning disorders. Limiting the study to one school allowed focus on one location. Second, the learners participating in the study have a documented diagnosis of specific learning disorder (SLD) by a qualified professional who followed the eligibility criteria for determining the qualification for SLD. Brown reviewed the clinical assessments and standardized assessments to confirm the diagnosis. Finally, all of the participants in the training group completed 30 hours of cognitive developmental training over a 7-week period for 60 minute sessions with a mediator trained in the *Equipping Minds Cognitive Development Curriculum.* While the recommended training with *EMCDC* is 60 hours, it was necessary to use an abbreviated format of the full program as the intervention was limited to 30 hours; this decision was made because there were only seven weeks available in the remaining school year before the *TerraNova* testing in April.

Limitations of Generalization

The generalization of the research findings had the following limitations. First, since all participants have a diagnosis of SLD, the findings of the research may not be generalizable to learners with other neurodevelopmental disorders. Second, since all of the participants have taken the *Terra Nova*, an annual academic assessment, the findings are not generalizable to learners with SLD who did not take the Terra Nova assessment.

Instrumentation

Data gathering for this study was conducted via a pre- and post-test using the *AWMA*-2, *KBIT*-2, and the *TerraNova*, an academic assessment. The *AWMA*-2 was designed to provide classroom teachers and specialists with a tool to quickly and easily

identify working memory difficulties.[5] The tests used in the computerized *AWMA*-2 battery were selected based on research "establishing that they provide reliable and valid assessments of verbal and visual-spatial short term and working memory."[6] The *AWMA*-2 was piloted with children and adults with autism spectrum disorders, ADHD, dyslexia, and motor disorders. The tests were also piloted on two groups of children: young children (4-5 years) and older children (9-10 years). The tests were adjusted to ensure that both the practice and test trials were age-appropriate and extensive practice trials with visuals were included. The *AWMA*-2 was field tested for five years and the feedback received from educators, psychologists and other professionals helped to refine the current version. The *AWMA*-2 was standardized to include individuals ages 5-79.[7]

The *Kaufman Brief Intelligence Test,* 2nd ed. (*KBIT*-2) is a brief intelligence test which measures verbal and nonverbal intelligence for individuals from 4 to 90 years of age. Administration can be done by trained technicians or paraprofessionals as well as qualified professionals. The test takes 15-30 minutes to administer and yields three scores: verbal, non-verbal, and an IQ composite. The verbal scale is composed of two subtests that assess receptive vocabulary and general information (Verbal Knowledge) as well as comprehension, reasoning, and vocabulary knowledge (Riddles). The non-verbal scale uses a Matrices subtest to measure the ability to solve new problems by accessing an individual's ability to complete visual analogies and understand relationships.[8]

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[5]Tracy Alloway, *Alloway Working Memory Assessment Manual*, 2nd ed. (London: Pearson Education, 2011), 1.

[6]Ibid., 11.

[7]Ibid., 12. See also Tracy Alloway and Ross Alloway, "Working Memory across the Lifespan: A Cross-Sectional Approach." *Journal of Cognitive Psychology* 25, no. 1 (2013), 84–93, accessed January 13, 2016, http://www.tandfonline.com/loi/pecp21.

[8]Alan Kaufman and Nadeen Kaufman, *Kaufman Brief Intelligence Test*, 2nd ed. (Bloomington, MN: PsychCorp, 2004), 1–4.

The *TerraNova* is a standardized academic assessment for 2nd-12th grade students in reading, mathematics, language, science, social studies, and spelling. The *TerraNova* is a respected and valid national achievement test for reading, mathematics, language, science, social studies, and spelling. *TerraNova* features 2011 norms from a national study. These are the most current and accurate norms, which allow educators to compare achievement results between groups of students. With item alignments to state standards, educators can review student results in the context of common school and district criteria.

Reliability and Validity

The test reliability of the *AWMA*-2 was measured on 128 students randomly selected across schools and age ranges between 5 years and mid-20s (mean = 10.4 years, SD =5 years) in the England. Table 3 illustrates the correlation coefficients for the test-retest reliability.[9] Four weeks separated the two test administrations. There was very little change in the scores of the students between the first and second time testing, indicating that the *AWMA*-2 is reliable.[10] Furthermore, validity of the *AWMA*-2 was evaluated by comparing student scores on the *AWMA*-2 to their scores on the *Wechsler Intelligence Scale for Children*, 4th ed. (*WISC*-IV). Alloway states, "There is a high degree of convergence in performance."[11]

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[9]*Alloway Working Memory Assessment Manual*, 15.

[10]Ibid., 16.

[11]*Alloway Working Memory Assessment Manual*, 60.

Table 3. Correlation coefficients for test-retest reliability of the *AWMA*-2

AWMA-2 Tests	*Retest Sample (n = 128)*
Verbal Short-term Memory Composite	.82
Verbal Working Memory Composite	.86
Visuospatial Short-term Memory Composite	.87
Visuospatial Working Memory Composite	.84

A test of construct stability was also conducted with primary children identified with poor working memory. The findings demonstrated that the *AWMA*-2 can accurately and consistently measure working memory capacity across an academic year.[12] Table 4 illustrates the correlation coefficients between memory components in the *AWMA*-2 at the beginning and end of the school year in children with working memory deficits.[13]

The reliability data for the *KIBT*-2 was presented for 23 age groups demonstrating the consistency of an individual's verbal, non-verbal, and IQ composite scores. The test reliability of the verbal score are high, ranging from .88 to .93 (mean=.91). The non-verbal score range from .76 to .89 (mean=.83) which are somewhat lower but within acceptable ranges. IQ composite test-retest stability was .90 over mean intervals of 22.5 to 30.8 days, with a mean performance increase of 4 points.

[12]*Alloway Working Memory Assessment Manual*, 15–16.

[13]Table 2 is a re-creation of the *Correlation Coefficients between Memory Components in the AWMA-2 at the Beginning and End of the School Year in Children with Working Memory Deficits.*

Table 4. Correlation coefficients between memory components in the *AWMA*-2 at the beginning and end of the school year in children with working memory deficits

AWMA-2 Tests	*Correlation Coefficient*
Verbal Short-term Memory	.59
Verbal Working Memory	.53
Visuospatial Short-term Memory	.54
Visuospatial Working Memory	.60

The verbal (r = .91) and non-verbal (r = .83) scales each showed similar increases on retesting. The *KBIT*-2's reliability of the IQ composite ranging from .89 to .96 is excellent with a mean of .93 across all ages with reliabilities increasing with age coefficients at different ages were adequate (.83 or higher) except for the non-verbal scale for the 4 through 12-year age groups (.76).[14] The *KBIT*-2 has been correlated with the Wechsler Abbreviated Scale of Intelligence and with the Wechsler Intelligence Scale for Children, 3rd and 4th ed., and the Wechsler Adult Intelligence Scale, 3rd ed..[15]

The Intervention Program: *Equipping Minds Cognitive Development Curriculum*

The *Equipping Minds Cognitive Development Curriculum*[16] (*EMCDC*) is based on the theory of Structural Cognitive Modifiability (SCM), Mediated Learning

[14]*Alloway Working Memory Assessment Manual,* 51–52.

[15]Ibid., 57–62. Detailed tables are presented showing the correlations with the Wechsler Test.

[16]Brown developed *EMCDC*; it includes a teacher workbook, student workbook, and instructional DVDs for use in the regular or special education classroom, church, or home environment by teachers, therapist, and parents.

Experience (MLE), and a biblical worldview. *EMCDC* is designed to strengthen existing neural connections and, more importantly, to create missing neural pathways that may inhibit one's ability to learn. *EMCDC* employs a holistic approach to cognitive development training through primitive reflex exercises, sensory-motor development exercises, and cognitive developmental exercises.

Primitive Reflex Exercises

Primitive reflexes provide the newborn with learning experiences, acting as a foundation for more complex muscle movements and later cognitive tasks. The reflexes are integrated in a sequential fashion the first year of life. The lack of integration can interfere with processing and affect learning, movement, and attention.[17] The visual motor system is intimately involved in the transition from primitive reflexes to control of movement patterns. By replicating the stages of development, the neural pathways can be strengthened, allowing for treatment to be successful. Per Sally Goddard, in *Reflexes, Learning, and Behavior*, "Most education and many remedial techniques are aimed at reaching higher centers in the brain. A neuro-developmental approach identifies the lowest level of dysfunction and aims therapy at that area. Once problems there have been remedied, the therapy attempts to build links from lower to higher centers through the use of specific stimulation techniques."[18]

Sensory-Motor Development

Sensory-motor development includes visual processing and auditory processing.[19] Visual processing includes visual tracking, visual localization and fixation,

[17]Sally Goddard-Blythe, *Reflexes, Learning, and Behavior* (Eugene, OR: Fern Ridge Press, 2002), 1–3.

[18]Goddard-Blythe, *Reflexes, Learning, and Behavior,* xv.

[19]A. Jean Ayers, *Sensory Integration and the Child* (Los Angeles: Western Psychological Services, 2005), 5.

visual coordination, and visual cognitive problem-solving skills. Students with poor visual-motors development have a hard time finding the words for objects they are viewing. Alternatively, if they are asked to get an object, they might look right at it and say they cannot find it. Although they are seeing the object, their brains are not efficiently processing the fact that they are seeing it.[20]

Auditory processing exercises include helping learners with fluency disorders, providing auditory feedback to help the students detect their errors (articulation, phonological processing), helping to regulate vocal intensity and self-monitor their fluency, and increasing their auditory memory. A student hears what is being said, but the brain does not process it fast enough or accurately enough. The result is that the student misunderstands what was said or it takes a long time for what was said to "click."[21] Sound therapy was developed by Alfred Tomatis to strengthen the auditory system.[22]

Cognitive Developmental Therapy

The cognitive developmental exercises set aside academic content to target cognitive functions. Learners participate in interactive games and paper-and-marker activities which are organized in a progressive and challenging manner to strengthen working memory, processing speed, perceptual reasoning, and comprehension. A trained mediator encourages the learner to "think aloud" and verbalize what they are processing and thinking. The structure for teaching within the curriculum is specified in the teacher workbook. While the model of mediation is the same for all learners, individualization will occur based upon the learner's progression.

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[20]Ayers, *Sensory Integration and the Child,* 116–20.

[21]Norman Doidge, *The Brain's Way of Healing* (New York: Viking Press, 2015), 297–301.

[22]Doidge, *The Brain's Way of Healing*, 301.

Student Participation Consent Form

The purpose of the Student Participation Consent Form was to confirm willingness of potential participants' parents to allow their child to participate in this research study. The first section consisted of the "Agreement to Participate" statement, which was read and affirmed by each participant's parent. The second section outlined the research procedures.[23]

Ethics Committee Process

The *Approvals for Using Human Subjects in Research* and the *Assessment of Risk to Human Subjects in Research* forms were submitted with the research proposal to the ethics committee for approval.

Research Procedures

The research design was implemented through the following steps (1) recruited study participants, confirmed diagnosis, confirmed completion of the 2014-2015 *TerraNova,* an academic assessment, and completed a Student's Participation Consent Form, (2) randomly assigned the participants into the training group and active control group, (3) administered a pre-test with the *AWMA*-2 and *KBIT*- 2, (4) completed intervention as necessary, (5) administered a post-test with the *AWMA*-2, *KBIT*-2, and *TerraNova*, (6) analyzed design and statistics, (7) evaluated the scoring on the *AWMA*-2, *KBIT*-2, and *TerraNova* and analyzed results in order to formulate findings and draw implications.

Recruit Study Participants

A school who serves learners with SLD and is trained in *EMCDC* initiated

[23]See appendix 1 for the form that was used in this study.

communication, in order to enlist potential participants in the study. It was confirmed that potential participants had a diagnosis of SLD and had completed the 2014-2015 *TerraNova* prior to the beginning of the study. The initial information about the study was delivered to the school to confirm their willingness to participate in the study. The parents of the potential participants completed a Student Participation Consent Form prior to beginning the study.

Random Assignment

Upon receipt of all the participation forms, the school administrators identified 32 students with a diagnosis of SLD, who had also completed the *TerraNova* in 2015. Following these criteria, 14 males and 18 females in 4^{th}-8^{th} grade were identified and randomly allocated to either the active control or the training group. Each participant was then assigned a number to be used to identify their assessment results throughout the study.

Administer the Pre-Test

Next, Brown, along with another qualified professional, administered the 32 pre-tests with the *KBIT*-2.[24] The *AWMA*-2, a computer based assessment, was administered to the 32 participants in the school computer lab by four qualified professionals.[25] The *KBIT*-2 and *AWMA*-2 were administered by Brown and five testers who met the qualifications.

Intervention

The 16 participants in the training group were placed in groups of two with

[24]In regard to the *KBIT*-2, 11 pretests were administered by Brown for the training group and 14 for the active control group. The other qualified tester administered 5 pretests for the training group and 2 for the active control group.

[25]The *AWMA*-2 allows for group testing. There were 3–4 testers who were with the eight groups containing four students.

the same *EMCDC* mediator for the duration of the study. There were four *EMCDC* mediators who provided the cognitive developmental training with the 16 participants for 60 minutes, 5 days a week for 7 weeks in a small group. The participants in the active control group received academic support with a teacher for 60 minutes, 5 days a week for 7 weeks in a small group. All participating learners continued to receive standard special educational support services as a result of their learning difficulties.

Administer the Post-Test

Brown, along with the same qualified professional who administered the pre-test, also administered a post-test with the *KBIT*-2 to the 32 participants.[26] The *AWMA*-2 post-test, a computer based assessment, was administered to the 32 participants in the school computer lab by four qualified professionals.[27] The *KBIT*-2 and *AWMA*-2 were administered by Brown, along with five testers who met the qualifications. The *TerraNova* was administered by the school administration and faculty. The completion of the *TerraNova* by the participants was confirmed.

To examine the gains as a function of cognitive developmental training, a statistician was employed who subtracted the pre-test scores from the post-test scores and compare the difference in scores (Time 2-Time 1) as a function of group. Scores below 0 indicate a worse performance on the post-test. Scores above 0 indicate improvements the group made after training.

Statistical Analysis

A statistician conducted a statistical analysis of the data collected. In order to answer questions 1, 2, and 3, a series of paired *t*-tests was used to determine the statistical

[26]In regard to the *KBIT*-2, Brown administered 12 post-tests for the training group and 6 for the active control group. The other qualified tester administered 5 pretest for the training group and 2 for the active control group.

[27]The *AWMA*-2 allows for group testing. There were 3-4 testers who were with the eight groups containing four students each for 1:1 or 1:2 oversights.

significance between the pre-test and post-test scores in both the active control and training group. In order to answer questions 4 and 5, a multiple linear regression was conducted on the difference of the pre and post-test scores as a function of their training group, age, and gender.

Table 5. Difference between pre-test scores and post-test scores (time 2-time 1) as a function of group

Measures	*Active Control*	*Training Group*
Verbal WM		
Visuospatial WM		
IQ: Verbal		
IQ: Non-Verbal		
Math		
Reading		
Language		
Science		
Social Studies		
Spelling		

Evaluate Findings and Draw Conclusions

The research analyzed and interpreted the findings to formulate findings and draw conclusions related to the study's guiding research questions. The strengths and weaknesses of the research design were evaluated. Additionally, the research questions, design overview, population, sample, delimitations, limitations of generalization, and instrumentation were evaluated.

CHAPTER 4

ANALYSIS OF FINDINGS

This research study examined the effect of the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*) on working memory in students diagnosed with a specific learning disorder (SLD) and whether an increase in working memory resulted in transfer effects within an educational setting, measured by standardized tests of academic attainment and non-verbal and verbal abilities. Additionally, this study explored differences with gender and age. This quantitative experimental research study utilized random sampling, an active control group, a training group, and pre- and post-tests to gather data from the participants. This chapter presents the compilation protocol, analysis of the data collected, and an analysis of the strengths and weaknesses of the research design.

Compilation Protocol

Compilation began with the recruitment and identification of learners with SLD and qualified mediators. Then, learners were randomly assigned into a training or active control group where they were administered pre-tests. Next, the intervention began as the training group received cognitive developmental training with *EMCDC*. After the intervention, post-tests were administered. A statistician conducted a statistical analysis of the data collected. This compilation occurred in five phases.

Phase 1 – Recruitment and Identification of Learners

A private school who serves learners with SLD and whose faculty are trained in *EMCDC* reached out to enlist potential participants in the study. The initial

information about the study was delivered to the school administration to confirm the willingness of the school, parents, and students to participate in the study. The school administration identified 32 potential participants in grades 4–8 who were between nine and fourteen years of age and had completed the *TerraNova* academic testing in 2015 at the school.[28]

The school administration provided the diagnostic assessments on each student which also included IQ scores with working memory subtest scores. It was confirmed that potential participants had a diagnosis of SLD and had completed the 2014-2015 *TerraNova* academic assessment prior to the beginning of the study. The parents of the 32 potential participants completed a Student Participation Consent Form prior to beginning the study. No compensation was given to study participants.

The eight training groups required 4 *EMCDC* mediators to be identified who lived in the area and who could commit to the study. Mediators were employed and trained in *EMCDC* for the study.[29] Additional training was provided for the four mediators, focusing on the cognitive exercises in the *EMCDC* which were to be used in the study. A background check was conducted on each mediator to comply with school policy.

Phase 2- Random Assignment and Pre-Testing

Upon receipt and examination of all the participation forms, the school administration randomly allocated the participants to either the active control or the

[28]The school uses the *TerraNova*, 3rd ed. Survey to measure reading, mathematics, science, social studies, and language. It is an abbreviated version of the complete battery and provides a general measure of academic achievement.

[29]Mediator 1 has a doctorate in Education and was certified in *EMCDC* in 2015. Mediator 2 has a MA, worked as high school teacher, and did 60 hours of training in *EMCDC*. Mediator 3 has a BS and has been employed by Brown as an educational specialist/mediator for five years. Mediator 4 has a BS and was trained in *EMCDC* in 2015.

training group.[30] The decision was made to place 16 participants in the training group with 7 males and 9 females; and 16 participants in the active control group with 7 males and 9 females. It should be noted that all 32 participants completed the entire research study. The desired minimum of 30 participants were obtained.

Next Brown, along with an *EMCDC* mediator who is qualified to administer the *KBIT*-2, administered a pretest with the *KBIT*-2. The *Kaufman Brief Intelligence Test,* 2nd ed. (*KBIT*-2) is a brief intelligence test which measures verbal and nonverbal intelligence for individuals from 4 to 90 years of age. Administration can be done by trained technicians or paraprofessionals as well as qualified professionals. The test takes 15-30 minutes to administer and yields three scores: Verbal, Nonverbal, and an IQ Composite. The Verbal scale is composed of two subtests that assess receptive vocabulary and general information (Verbal Knowledge) as well as comprehension, reasoning, and vocabulary knowledge (Riddles). The Nonverbal scale uses a Matrices subtest to measure the ability to solve new problems by accessing an individual ability to complete visual analogies and understand relationships.[31] The testing took place at the school and took approximately 30 minutes for each participant to complete.

Qualified professionals, which included the school principal, administered the *AWMA*-2 on a computer in the school's computer lab. At the time of the pre-test the participant's allocation into the groups had not been disclosed to anyone testing the participants. The *AWMA*-2 was designed to provide classroom teachers and specialists with a tool to quickly and easily identify working memory difficulties.[32] The tests used in

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[30]The school administrators identified 32 students with a diagnosis of SLD, who had completed the *TerraNova* in 2015, and whose parents were supportive of their child's participation. Following these criteria, 14 males and 18 females in 4th-8th grade were identified. The school administrator then randomly placed them into the training or active control.

[31]Alan Kaufman and Nadeen Kaufman, *Kaufman Brief Intelligence Test*, 2nd ed. (Bloomington, MN: PsychCorp, 2004), 1–4.

[32]*Alloway Working Memory Assessment Manual*, 2nd ed. (London: Pearson Education, 2011), 1.

the computerized *AWMA*-2 battery were selected based on research "establishing that they provide reliable and valid assessments of verbal and visual-spatial short term and working memory."[33] The *AWMA*-2 was piloted with children and adults with autism spectrum disorders, ADHD, dyslexia, and motor disorders. The tests were also piloted on two groups of children: young children (4-5 years) and older children (9-10 years). The tests were adjusted to ensure that both the practice and test trials were age-appropriate and extensive practice trials with visuals were included. The *AWMA*-2 was field tested for five years and the feedback received from educators, psychologists and other professionals helped to refine the current version. The *AWMA*-2 was standardized to include individuals ages 5–79.[34]

As noted, all of the participants had completed the *TerraNova* academic testing in 2015. The *TerraNova* is a standardized academic assessment for 2nd-12th grade students in reading, mathematics, language, science, social studies, and spelling. The *TerraNova* is a respected and valid national achievement test for reading, mathematics, language, science, social studies, and spelling. *TerraNova* features 2011 norms from a national study. These are the most current and accurate norms, which allow educators to compare achievement results between groups of students. With item alignments to state standards, educators can review student results in the context of common school and district criteria. The academic assessment the school already had in place was used, as it would have been a burden on the school and participants to add an additional academic assessment.

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[33]*Alloway Working Memory Assessment Manual*, 11.

[34]Ibid., 12. See also Tracy Alloway and Ross Alloway, "Working Memory Across the Lifespan: A Cross-Sectional Approach," *Journal of Cognitive Psychology* 25, no. 1 (2013): 84–93, accessed January 13, 2016, http://www.tandfonline.com/loi/pecp21.

Phase 3- Intervention

The participants in the training group received cognitive developmental training for 60 minutes, 5 days a week for 7 weeks in a small group of two participants with a trained mediator using *EMCDC*. This curriculum employs a holistic approach to cognitive development training through primitive reflex exercises, sensory-motor development exercises, and cognitive developmental exercises. The *Maintaining Brains Everyday* DVD for the primitive reflex exercises[35] and the fear paralysis exercises[36] were done by the participants at home or at school for 15 minutes a day. The sensory-motor development exercises included the use of sound therapy[37] which the participants wore during the one-hour intervention sessions while doing the cognitive developmental exercises. The mediators follow an abbreviated format of the *EMCDC* full program as the intervention was limited to 30 hours. Brown observed the training groups on a weekly basis to assure fidelity to the *EMCDC* research protocol, answer questions from the mediators, and observe the participants' progression. The participants in the active control group received academic support with a teacher for 60 minutes, 5 days a week for 7 weeks in a small group. All participating learners continued to receive standard special educational support services as a result of their learning difficulties.

Phase 4- Administer the Post-Test

Qualified *EMCDC* staff administered a post-test with the *KBIT*-2 which took approximately 30 minutes for the active control group as noted in the pretest. However, the training group took approximately 45 minutes to complete the post-test. The *KBIT*-2

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[35]Kathy Johnson, *Maintaining Brains Every Day*, DVD, http: www.pyramidofpotential.com.

[36]Harald Bloomberg and Moira Dempsey, *Movements That Heal*: *Rhythmic Movement* (Sunnybank Hills, Australia: Book Pals, 2011), 195.

[37]Sound therapy is therapeutic classical music designed to increase auditory processing.

is an untimed test and takes approximately 15 to 30 minutes to administer.[38] Those administering the test noted more thoughtful responses[39] by those in the training group. The *AWMA*-2 was administered on a computer by the school principal and qualified professionals. The *TerraNova* academic testing was administered by the school administration and faculty over a 2-week period. The school principal confirmed the completion of the *TerraNova* by the participants.

Phase 5 – Analysis of the Data

The results of all three tests were compiled on Excel spreadsheets. A statistician then conducted a statistical analysis of the data collected on the *AWMA-2*, the *KBIT*-2, and the *TerraNova*.

Research Question Synopsis

1. What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum*?
2. What, if any, are the effects of changes in working memory to academic abilities in learners using the *Equipping Minds Cognitive Development Curriculum*?
3. What, if any, is the effect of working memory on non-verbal and verbal abilities?
4. What, if any, is the effect of gender of the learner on working memory in students using the *Equipping Minds Cognitive Development Curriculum*?
5. What, if any, is the effect of the participant's age on working memory using the *Equipping Minds Cognitive Development Curriculum*?

Research Question 1

Research Question 1 asked, "What, if any, are the effects on working memory when

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[38]Kaufman, *Kaufman Brief Intelligence Test,* 1–4.

[39]The participants in the training group were observed taking more time to think about their responses on all three areas of the *KBIT*-2. The participants would ask a question to be repeated, which is allowed on the *KBIT*-2. Some of the participants expressed their thought process verbally and how they were deducing their answer.

applying the *Equipping Minds Cognitive Development Curriculum*?"

Table 6. Working memory scores for SLD

Measures	*Active Control*			*Training Group*		
	M	$t_{(15)}$	Pre-to-Post (p)	M	$t_{(15)}$	Pre-to-Post (p)
Verbal WM	2.125	1.152	.2671	3.875	2.459	.0265 *
Visuo-Spatial WM	-1.063	-0.327	.7480	4.313	1.519	.1495

NOTE: M = Mean of the post- minus pre-test scores; *p* = *p*-value for the two-mean *t*-tests for the difference in pre- and post-test scores; * = significant at the 5% level

Table 7. Regression analysis: effect of training on working memory scores for SLD

Measures	*Training B (S.E.)*	*p*	r^2
Verbal WM	1.750 (2.425)	.4761	.0171
Visuospatial WM	5.375 (4.313)	.2223	.0492

NOTE: B = regression coefficient of the training effect on the difference in post- minus pre-test scores; SE = standard error of the regression coefficient; *p* = *p*-value for the significance of the training on the difference in test scores; * = significant at the 5% level

Findings

The results in table 6 demonstrate that there was a statistically significant improvement in Verbal Working Memory test scores for the students in the training group ($t_{(15)} = 2.459$, $p = .0265$). Students in the training group also showed improvement on the Visuospatial Working Memory but the improvements were not statistically significant. The students in the active control group only showed improvement in Verbal

Working Memory but the improvements were not statistically significant and showed a decrease in Visuospatial Working Memory.

The results in table 7 demonstrate that we are unable to conclude that the training provided by the *Equipping Minds Cognitive Development Curriculum* made a significant effect on the improvement in test scores for the students on the two Working Memory tests. While the average gain made by students in the training group was larger than the active control group on each Working Memory test, the difference that can be attributed to the training is not statistically significant.

In response to Research Question 1, "What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum*?" one must conclude there is no statistically significant effect on working memory when applying the *Equipping Minds Cognitive Development Curriculum*.

Research Question 2

Research Question 2 asked, "What, if any, are the effects of changes in working memory to academic abilities in learners using the *Equipping Minds Cognitive Development Curriculum*? (See table 8 on the following page.)

Findings

The results in table 8 demonstrate that there was a statistically significant improvement in the reading ($t_{(15)} = 2.249$, $p = .0399$), science ($t_{(15)} = 4.050$, $p = .0010$), and spelling ($t_{(15)} = 3.735$, $p = .0019$) test scores for the students in the training group. Students in the training group showed improvement on each academic test aside from computation, but the other improvements were not statistically significant. The

improvement shown by students on any of the academic tests in the active control group was not statistically significant.

Table 8. Grade equivalent academic scores for SLD

Measures	*Active Control*			*Training Group*		
	M	$t_{(15)}$	Pre-to-Post (p)	M	$t_{(15)}$	Pre-to-Post (p)
Reading	0.250	0.324	.7508	1.069	2.249	.0399 *
Vocabulary	0.150	0.204	.8411	0.806	1.241	.2336
Language	1.081	1.674	.1148	1.169	1.722	.1055
Mechanics	-0.594	-0.754	.4624	1.131	1.498	.1549
Math	0.819	1.622	.1256	0.500	1.191	.2521
Computation	0.775	1.449	.1679	-0.113	-0.234	.8181
Science	0.019	0.032	.9745	1.438	4.050	.00105 **
Social Studies	0.844	1.260	.2268	0.950	1.239	.2345
Spelling	0.656	1.361	.1935	1.875	3.735	.00199 **

NOTE: M = Mean of the difference in the grade equivalencies of the pre- and post-test scores; *p* = *p*-value for the two mean t-tests for pre- and post-test scores; * = significant at the 5% level; ** = significant at the 1% level

Table 9. Regression analysis: effect of training
on the grade equivalent academic scores for SLD

Measures	*Training B (S.E.)*	*P*	r^2
Reading	0.819 (0.907)	.3740	.0264
Vocabulary	0.656 (0.981)	.5088	.0147
Language	0.0875 (0.937)	.9262	.00029
Mechanics	1.725 (1.091)	.1244	.0769
Math	-0.319 (0.656)	.6308	.0078
Computation	-0.888 (0.719)	.2267	.0483
Science	1.419 (0.678)	.0450*	.1273
Social Studies	.1063 (1.018)	.9176	.00036
Spelling	1.219 (.6960)	.0901	.0927

NOTE: B = regression coefficient of the training effect on the difference in post- minus pre-test scores; SE = standard error of the regression coefficient; *p* = *p*-value for the significance of the training on the difference in test scores; * = significant at the 5% level

The findings in table 9 demonstrate that we are able to conclude that the training provided by the *Equipping Minds Cognitive Development Curriculum* made a significant effect on the improvement in test scores for the students on the science test (r^2=.1273, *p* =.0450). While the average gain made by students in the training group was larger than the active control group on every test other than math and computation, the difference that can be attributed to the training is not statistically significant for any of the other tests.

In response to Research Question 2, “What, if any, are the effects of changes in working memory to academic abilities in learners using the *Equipping Minds Cognitive*

Development Curriculum?" one must conclude that there were no statistically significant changes to working memory using the *Equipping Minds Cognitive Development Curriculum*, therefore there cannot be correlation between working memory and the statistically significant changes found in the science scores.

Research Question 3

Research Question 3 asked, "What, if any, is the effect of working memory on non-verbal and verbal abilities?"

Table 10. Verbal and non-verbal scores for SLD

Measures	*Active Control*			*Training Group*		
	M	$t_{(15)}$	Pre-to-Post (p)	M	$t_{(15)}$	Pre-to-Post (p)
Verbal	5.313	2.979	.00937 **	13.438	5.179	.000112 ***
Non-Verbal	1.125	0.308	.7620	15.813	6.015	.0000237 ***
IQ Composite	1.500	0.580	.5706	16.813	7.239	.00000288 ***

NOTE: M = Mean of the post- minus pre-test scores; *p* = *p*-value for the two-mean *t*-tests for the difference in pre- and post-test scores; * = significant at the 5% level; ** = significant at the 1% level; *** = significant at the .1% level

Findings

The findings in table 10 demonstrate that there was a statistically significant improvement in Verbal test scores for the students in the active control group ($t_{(15)}$ =2.979, p =.0094 and the training group ($t_{(15)}$ =5.179, p =.0001). The improvement shown by students in the training group on the Non-Verbal test ($t_{(15)}$ =6.015, p <.0001) and the IQ Composite ($t_{(15)}$ =7.239, p <.0001) was statistically significant, while the

improvement shown by students in the active control group was not statistically significant on either the Non-Verbal test or the IQ Composite.

Table 11. Regression analysis: effect of training on verbal and non-verbal scores for SLD

Measures	*Training B (S.E.)*	*P*	r^2
Verbal	8.125 (3.149)	.0150 *	.1816
Non-Verbal	14.688 (4.495)	.00272 **	.2624
IQ Composite	15.313 (3.476)	.000124 ***	.3927

NOTE: B = regression coefficient of the training effect on the difference in post- minus pre-test scores; SE = standard error of the regression coefficient; *p* = *p*-value for the significance of the training on the difference in test scores; * = significant at the 5% level; ** = significant at the 1% level; *** = significant at the .1% level

The findings in table 11 conclude that the training provided by the *Equipping Minds Cognitive Development Curriculum* made a significant effect on the improvement in test scores for the students for the Verbal (r^2 = .1816, p= .0150) Non-Verbal (r^2 = .2624, p= .0027) and IQ Composite (r^2 = .3927, p= .0001).

In response to Research Question 3, "What, if any, is the effect of working memory on non-verbal and verbal abilities?" one must conclude there were no statistically significant changes to working memory, there cannot be a correlation between working memory and the statistically significant changes found in the verbal, nonverbal and IQ composite scores.

Research Questions 4 and 5

Research Question 4 asked, "What, if any, is the effect of the participant's gender on working memory using the *Equipping Minds Cognitive Development*

Curriculum?" Research Question 5 asked, "What, if any, is the effect of the participant's age on working memory using the *Equipping Minds Cognitive Development Curriculum*?" An interaction regression model can determine the significance of the training interacting with gender and age on the differences between pre- and post-test scores.

Table 12. Regression output: significance of training interacting with gender and age on scores

Measures	*Training: Age B (S.E.)*	*P*	*Training: Gender(M) B (S.E.)*	*p*	r^2
Verbal WM	5.714 (2.396)	.0247 *	-0.0973 (5.200)	.9852	.1941
Visuospatial WM	-6.604 (4.311)	.1377	8.748 (9.358)	.3585	.2020
Reading	-0.127 (0.903)	.8893	4.345 (1.959)	.0355 *	.1901
Vocabulary	0.805 (1.049)	.4496	-1.613 (2.276)	.4849	.0547
Language	0.206 (0.941)	.8282	3.815 (2.043)	.0731 #	.1526
Mechanics	0.366 (1.117)	.7456	-0.517 (2.424)	.8326	.1877
Math	-0.056 (0.653)	.9318	2.319 (1.418)	.1141	.1744
Computation	-0.281 (0.770)	.7186	0.161 (1.671)	.9240	.0835
Science	-0.552 (0.651)	.4047	2.886 (1.413)	.0514 #	.3242
Social Studies	0.030 (1.056)	.9777	0.787 (2.291)	.7338	.0974

Table 12 continued

Spelling	0.484 (0.715)	.5046	-2.230 (1.552)	.1626	.1957
Verbal	-3.364 (3.110)	.2893	8.560 (6.322)	.1874	.3660
Non-Verbal	1.229 (4.199)	.7721	-6.607 (8.536)	.4459	.4890
IQ Composite	-4.006 (3.506)	.2636	5.485 (7.128)	.4486	.5094

NOTE: B = regression coefficient for the interaction of term of Training with Age or with Gender; SE = Standard Error of regression coefficient; p = p-value for the significance of the interaction term; * = significant at the 5% level

Findings

The findings in table 12 signify that training interacting with gender was not a significant factor in affecting how the students responded to the training provided by the *Equipping Minds Cognitive Development Curriculum*, as evidenced by the improvement shown on the tests in verbal and visuospatial working memory, verbal and non-verbal abilities, and IQ Composite. However, gender did play a significant role in two of the Academic tests: reading (r^2 = .1901, p= .0355) and science (r^2 = .3242, p= .0514). In each of these cases, the improvement in scores was more significant for males in the training group than for females. There were 7 males in the training and the active control group and 9 females in the training and in the active control group.

Thus, in response to Research Question 4, "What, if any, is the effect of the participant's gender on working memory using the *Equipping Minds Cognitive Development Curriculum*?" one must conclude there were no statistically significant changes to working memory, there cannot be a correlation between working memory and the participant's gender when using *the Equipping Minds Cognitive Development Curriculum*.

The findings in table 12 signify that training interacting with age is a significant predictor in the difference in test scores only for the Verbal Working Memory test (r^2 = .1941, p = .0247). The students ranged from 9 to 14 years of age. More specifically, older students in the training group were more likely to exhibit significant improvement in test scores on the Verbal Working Memory test. Age was not a significant factor in affecting how the students responded to the training provided by the *Equipping Minds Cognitive Development Curriculum*, as exhibited by the improvement of test scores, for any of the other tests.

In response to Research Question 5, "What, if any, is the effect of the participant's age on working memory using the *Equipping Minds Cognitive Development Curriculum*?" one must conclude there were no statistically significant changes to working memory, there cannot be a correlation between working memory and the participant's age.[40]

Evaluation of the Research Design

This true experimental research design allowed the analysis of working memory, verbal and nonverbal abilities, and the transfer to academics using *EMCDC*. An evaluation of both, the strengths and weaknesses of the research design are presented.

Strengths of the Research Design

The greatest strength of the research design was the ability to have a true experimental design with a random allocation of participants into a training and active control group. The active control group participants received academic support with a teacher for 60 minutes, 5 days a week for 7 weeks in a small group strengthening the results. The statistical analysis was done by a statistician, and a regression output was

[40]For additional statistical findings from the study, see appendix 2. Table A1 contains findings from group profiles and means for pre and post training assessments.

used to determine if the difference in pre- to post-test scores could be statistically attributed to the training strengthening the validity of the intervention with *EMCDC*.

At the time of the pre-test the participant's allocation into the groups had not been disclosed to the testers, which was also a strength. In response to critiques of working memory computer training programs, this study used a human mediator instead of a computer for the cognitive intervention, far transfer effects were measured, and there was an active control group.[41] Another strength of the design was the cooperative attitude, commitment, and fidelity to the intervention by the school administration, faculty, parents, mediators, and participants. All 32 participants completed the entire study. The participants in the training and active control group had rapport with the testers, which is another strength of the study. Kauffman states, "Establishing a relationship that brings out the examinee's best performance is one of the most important requirements for accurate individual testing."[42] Finally, with respect to near and far transfer effects, there are a limited number of research studies that examine verbal and visuospatial working memory, verbal and nonverbal abilities, and academic attainments in nine areas in students with SLD which is the final strength of this study.[43]

Weaknesses of the Research Design

The major weakness of the research design was the time constraint. For optimum results from the *EMCDC*, Brown recommends a minimum of 60 hours of intervention over a 12 to 24-week period.[44] Though approval was granted to begin the

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[41]M. Melby-Lervag and C. Hulme, "Is Working Memory Training Effective? A Meta-Analytic Review," *Developmental Psychology* 49, no. 2 (2013): 270–91.

[42]*Kaufman Brief Intelligence Test,* 5.

[43]The author is unaware of any study which has examined nine academic areas after cognitive training with students of any learning disability.

[44]Brown is the creator and author of the *Equipping Minds Cognitive Development Curriculum*. Over the last 6.5 years she has seen numerous children and adults complete the program, which typically takes 12-24 weeks to complete 60 hours for optimum results that generalize to academic, cognitive, social, and behavior skills. She has also observed gains in working memory on the *AWMA*-2 at the Equipping

study in February of 2016, the participants were limited to a 9-week period to complete the pre-testing with the *AWMA*-2 and *KBIT*-2, the 30 hours of intervention, and the post-testing with the *AWMA*-2 and *KBIT*-2. The participants had Spring break the first week of April and then the *TerraNova* testing. Finally, the time period for the study did not allow follow-up assessments to determine if the gains were maintained.

Minds center with students with SLD after 60 hours of *EMCDC*.

CHAPTER 5

CONCLUSIONS

According to Richard Davidson, neuroscientist at University of Wisconsin—Madison, "Neuroplasticity is the most important general discovery in all of neuroscience in the last decade. The brain is built to change in response to experience and in response to training. And it is really because of this active neuroplasticity that we can learn."[1] This discovery has led to a growing interest in training working memory capacity. The relationship between working memory, verbal and nonverbal abilities, and academics has received a great deal of support in recent literature. This chapter reviews the purpose of the research, findings related to the five research questions, offers relevant implications, contributes to the precedent literature, lists limitations of the research method, recommends applications for practice, and suggests recommendations for further research.

Research Purpose

The purpose of this experimental study was to examine the effect of the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*) on working memory in students diagnosed with specific learning disorder (SLD),[2] a neurodevelopmental learning disorder, and whether an increase in working memory resulted in transfer effects within an educational setting, measured by standardized tests of academic attainment and

[1]Miriam Boleyn-Fitzgerald, *Pictures of the Mind: What the New Neuroscience Tells Us about Who We Are* (Upper Saddle River, NJ: Pearson Education, 2010), 21–22.

[2]American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed. (Washington, DC: American Psychiatric Publishing, 2013), 66–74. Difficulties learning and using academic skills in the areas of reading, comprehension, mathematics, spelling, and written expression.

non-verbal and verbal abilities. Additionally, this study explored differences based on gender and age.

Research Questions

The following five questions were answered by this study,

1. What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum*?
2. What, if any, are the effects of changes in working memory to academic abilities in learners using the *Equipping Minds Cognitive Development Curriculum*?
3. What, if any, is the effect of working memory on non-verbal and verbal abilities?
4. What, if any, is the effect of gender of the learner on working memory in students using the *Equipping Minds Cognitive Development Curriculum*?
5. What, if any, is the effect of the participant's age on working memory using the *Equipping Minds Cognitive Development Curriculum*?

Conclusions and Implications of the Research

Guided by the five research questions, this section will discuss the findings and implications of the present research as related to the precedent literature including the research on working memory, structural cognitive modifiability, and mediated learning in the fields of psychology and education. The following list is a summary of the implications derived from the researcher's evaluation of the analysis of the findings:

1. Students with SLD have low working memory scores which impact academic performance. (See research question 1).
2. Working memory training does not seem to have a causative effect in relationship to verbal, nonverbal, and academic abilities when using *EMCDC* for 30 hours of intervention. (See research question 1).
3. In the context of this study, 30 hours of intervention using the *EMCDC* did not impact verbal and visuospatial working memory to the extent seen in the clinical setting when 60 hours of intervention are used. (See research question 1).
4. Thirty hours of intervention with *EMCDC* significantly improves science scores demonstrating far transfer effects in learners with a SLD. (See research question 2).
5. *EMCDC* increases cognitive abilities of verbal, nonverbal, and IQ composite despite

insignificant measurable changes in working memory. (See research question 3).

6. Human-mediated learning using a cognitive development curriculum, *EMCDC*, increases cognitive abilities of verbal, nonverbal, and IQ composite scores in learners with a SLD. (See research question 3).

7. Gender is not a significant factor in a student's response to the training provided by *EMCDC* in verbal and visuospatial working memory, verbal and non-verbal abilities, and IQ Composite. (See research question 4).

8. *EMCDC* impacts males more significantly than females in reading and science. (See research question 4).

9. Older students are more likely to exhibit significant improvement in test scores on the Verbal Working Memory test. (See research question 5).

Research Question 1

The first research question examined the effects on working memory when applying the *EMCDC*. The implication suggested by research over the last twenty years is that children with a SLD have low working memory (WM) which impacts academic performance. To determine the participants working memory scores, the *AWMA*-2 was the assessment used for both pre-test and post-test scores for working memory. The verbal working memory scores for the pre- and post-testing for participants in the training group was statistically significant ($t_{(15)} = 2.459$, $p = .0265$) and while the active control group made gains in verbal working memory, the change was not statistically significant. In regard to the visuospatial working memory pre- and post-testing, the training group continued to make gains but the active control group decreased. However, the regression analysis demonstrated it is not possible to conclude that the training provided by *EMCDC* had a significant effect on the participants in verbal or visuospatial working memory in the 30 hours of intervention during a 7-week period. Therefore, the implication from the present research is that working memory training does not have a causative effect in relationship to verbal, nonverbal, and academics abilities when using *EMCDC*.

This finding is counter to the findings in the research studies regarding

working memory computer training programs. First, Alloway, Bibile and Lau's research study[3] suggests that there is a causative effect between training of working memory to verbal and visuospatial working memory abilities, verbal and nonverbal abilities, and spelling abilities.[4] In this experimental study with *Jungle Memory*, verbal and visuospatial working memory scores increased significantly at a high frequency rate of intervention of four times a week for 8 weeks.[5] Second, the working memory computer training program *Cogmed* states the effective training time is 30–40 minutes per day, 5 days a week for 5 weeks, for a total of approximately 15 hours.[6] Furthermore, in the context of this study, 30 hours of intervention using the *EMCDC* did not impact verbal and visuospatial working memory to the extent seen in the clinical setting when 60 hours of intervention are used[7] and as indicated in the case study with "Marie."[8]

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[3]T. P. Alloway, V. Bibile, and G. Lau, "Computerized Working Memory Training: Can it Lead to Gains in Cognitive Skills in Students?" *Computers and Human Behavior* 29 (2013): 632–38.

[4]T. P. Alloway, *Improving Working Memory: Supporting Students' Learning* (Thousand Oaks, CA: Sage Publications, 2011), 10–14; Susanne M. Jaeggi et al., "Improving Fluid Intelligence with Training on Working Memory," *Proceedings of the National Academy of Sciences* 105 (2008): 6829–33, accessed December 15, 2015, http://www.pnas.org/content/105/19/6829.long; T. Klingberg, "Training and Plasticity of Working Memory," *Trends in Cognitive Sciences* 14, no. 7 (2010): 317–24.

[5]Alloway, Bibile, and Lau, "Computerized Working Memory Training," 632–38.

[6]T. Klingberg, "Training and Plasticity of Working Memory," *Trends in Cognitive Sciences* 14, no. 7 (2010), 317–24.

[7]Over the last 6.5 years, Brown, as creator of *Equipping Minds Cognitive Development Curriculum*, has seen numerous children and adults complete the program; it typically takes 12–24 weeks to complete 60 hours for optimum results which generalize to academic, cognitive, social, and behavior skills. Brown has also observed gains in working memory on the *AWMA*-2 at the Equipping Minds center with students with SLD after 60 hours of *EMCDC*.

[8]Carol T. Brown, "Equipping Minds for Christian Education: Learning from Neuroscience for Christian Educators," *Christian Education Journal* 13, no. 1 (2016): 147–68. Carolyn Mervis stated that in her research with students with Down syndrome, she was not aware of any case where cognitive developmental exercises had generalized to academics in a nine-week period. Mervis performed a full cognitive assessment on Marie. Mervis stated that the gains in processing and working memory were greater than she had ever seen before as indicated on the psychological testing. Carolyn Mervis, e-mail to the author, April 2011.

Research Question 2

Having found that working memory did not significantly increase, significant gains were not expected in academic abilities. However, this assumption was incorrect. The results demonstrated that there was a statistically significant improvement in the reading ($t_{(15)} = 2.249$, $p = .0399$) science ($t_{(15)} = 4.050$, $p = .0010$) and spelling ($t_{(15)} = 3.735$, $p = .0019$) test scores for the students in the training group without significant gains in working memory. Students in the training group showed improvement on each academic test aside from computation, but the other improvements were not statistically significant. There was no statistically significant improvement on any of the academic tests in the active control group.

The regression analysis reveals that the training provided by the *Equipping Minds Cognitive Development Curriculum* made a statistically significant improvement in test scores for the students on the science test ($r^2 = .1273$, $p = .0450$) and tend toward statistical significance on the spelling test ($r^2 = .0927$, $p = .0901$).

It is important to note that the annual academic assessment with the *TerraNova* had been given in April of 2015 and April of 2016. The participants in the study had attended the same school for students with learning challenges for a minimum of two years. The teachers and interventionist at the participants' school are trained in numerous reading, mathematics, language, science, and spelling curriculums designed for students with learning challenges. The participants in the training and active control group had received identical academic instruction for the entire school year. While the training group had participated in the study from February 2016-April 2016, *EMCDC* is void of academic content. While the findings were not statistically significant for language and reading, the training group did make stronger gains in these areas than the active control group. This implies that thirty hours of intervention with *EMCDC* significantly improves science scores demonstrating far transfer effects in learners with a SLD. In the case study

with “Marie” who did *EMCDC*, the strongest academic gain was in science after completing 45 hours of intervention.

As noted, Alloway, Bibile and Lau's study demonstrated significant gains in spelling as did the current research. Alloway et al. also found there were no significant gains in mathematics scores. Mathematic computation scores were the one academic area which decreased in the current study while the other areas all increased. These findings imply that with or without an increase in working memory, mathematic scores may be the most difficult to increase in a 7-8 week time period. In the case study with “Marie” who did *EMCDC*, mathematics was the least significant gain at 45 hours. After the completion of 60 hours, "Marie's" mathematics scores made significant academic gains and continued to increase over the next four years, as she tested in the 39th percentile on the Stanford 10 in mathematics.

Research Question 3

Having found that working memory did not significantly increase, significant gains in verbal and nonverbal abilities and IQ composite were not expected. The literature on working memory training shows minimal transfer to verbal and nonverbal abilities even when gains in working memory are significant.[9]

The findings have implications to a question that was not being asked: “Can IQ be increased in learners with a SLD using *EMCDC* independent of gains in working memory?” There was a statistically significant improvement in verbal test scores for the students in the active control group ($t_{(15)} = 2.979$, $p = .0094$) and the training group ($t_{(15)} = 5.179$, $p = .0001$). Applying the regression output, the improvement shown by students in the training group on the non-verbal test and the IQ composite was extremely statistically significant, with $p < .0001$ and $<.0001$, respectively, while the improvement

[9]M. Melby-Lervag and C. Hulme, “Is Working Memory Training Effective? A Meta-Analytic Review,” *Developmental Psychology* 49, no. 2 (2013): 270–91.

shown by students in the active control group was not statistically significant on the non-verbal test nor on the IQ composite.

The research concludes, and the findings support, that the training provided by the *Equipping Minds Cognitive Development Curriculum* makes a significant effect on the improvement in test scores for the students in verbal (r^2 =.1816, p = .0150), non-verbal (r^2 =.2624, p = .0027), and IQ (r^2 =.3927, p <.0001). This implies that *EMCDC* increases verbal, nonverbal, and IQ composite cognitive abilities despite insignificant measurable changes in working memory.

This finding is also counter to the precedent literature which states that working memory is the skill that gives an individual the advantage of managing all this information and is a stronger indicator of a learner's academic and personal potential than an IQ test.[10] The results of the current research support training working memory, processing, comprehension, and reasoning abilities to increase verbal, nonverbal, and IQ composite cognitive abilities; thus it is helpful to observe what elements distinguish *EMCDC*.

EMCDC is based on Feuerstein's theories of Structural Cognitive Modifiability (SCM), Mediated Learning Experience (MLE), and a biblical worldview. The cognitive developmental exercises in *EMCDC* set aside academic content to target the cognitive functions. Learners participate in interactive games and paper-and-marker activities which are organized in a progressive and challenging manner to strengthen four areas: working memory, processing speed, perceptual reasoning, and comprehension. A trained mediator encourages the learner to "think aloud" and verbalize what they are processing and thinking. By using mediation, these cognitive functions can be corrected, formed and modified in significant ways enabling students to reach their full cognitive

[10]Tracy Packiam Alloway and Ross Alloway, *The Working Memory Advantage (*New York: Simon and Schuster, 2013), 16. See also Alloway and Alloway, "Investigating the Predictive Roles of Working Memory and IQ in Academic Attainment," 27.

potential.[11] This implies human-mediated learning using a cognitive development curriculum, such as *EMCDC*, increases cognitive abilities of verbal, nonverbal, and IQ composite scores in learners with a SLD.

Research Question 4

The fourth research question examined whether or not participants' gender impacted working memory, when using the *EMCDC*. The findings indicate that gender was not a significant factor in how the students responded to the training provided by the *Equipping Minds Cognitive Development Curriculum*, as evidenced by the improvement shown on the tests in verbal and visuospatial working memory, verbal and non-verbal abilities, and IQ composite.

However, gender did play a significant role in two of the academic tests: reading (r^2 = .1901, p= .0355) and science (r^2 = .3242, p= .0514). In each of these cases, the improvement in scores was more significant for males in the training group than for females. There were 7 males in the training and the active control group and 9 females in the training and in the active control group. These findings imply *EMCDC* impacts males more significantly than females in reading, language, and science.

Research Question 5

The fifth research question examined how a learner's age influenced working memory when using the *EMCDC*. The findings signify that training interacting with age is a significant predictor in the difference in test scores only for the verbal Working Memory test (r^2 = .1941, p = .0247). The students ranged from 9 to 14 years of age. More specifically, the findings imply older students are more likely to exhibit significant improvement in test scores on the verbal Working Memory test. Age was not a

[11]Reuven Feuerstein, Refael S. Feuerstein, and Louis H. Falik, *Beyond Smarter: Mediated Learning and the Brain's Capacity for Change* (New York: Teachers College Press, 2010), 83–84.

significant factor in affecting how the students responded to the training provided by the *Equipping Minds Cognitive Development Curriculum*, as exhibited by the improvement of test scores, for any of the other tests.

In summary, these findings confirm Feuerstein's belief that intelligence is changeable and modifiable regardless of age, neurodevelopmental conditions, genetics, and developmental disabilities.[12] He also believed that change was possible at any age in contrast to the accepted concept of the *critical period* or *critical age*, which states that if a person has not reached a particular function by certain age he/she no longer has the ability to learn that skill. The conclusions and implications of the research study demonstrate the training provided by the *Equipping Minds Cognitive Development Curriculum* make a significant effect on the improvement in test scores for students with SLD in verbal, non-verbal, and IQ composite and transfer to the academic subject of science. The results support the theories of MLE and SCM and the research of Feuerstein. *EMCDC*'s use of a human mediator and cognitive developmental exercises, which are based on a biblical worldview and Feuerstein's cognitive functions, have a greater impact than working memory training by a computer program alone.

Research Limitations

In addition to the limits of generalization enumerated in chapter 3, which state the findings of the research ought not to be generalized to learners without SLD diagnosis and the findings are not generalizable to learners with SLD without an annual academic assessment, the findings and conclusions expressed in this research study should include the following additional limitations:

1. Due to the sample size of 32 participants, the results may not be indicative of all learners with a SLD.

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[12]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 8–9.

2. Due to the students attending a private school for learners with learning challenges with small classroom sizes, the results may not be indicative of learners in a private school for learners without learning struggles, public schools, or learners in large classroom sizes.

3. Due to the learners being 9 to 14 years of age, the results may not be indicative of learners younger than 9 or older than 14 years of age.

Contribution of Research to the Precedent Literature

Over the last twenty years there has been an increased interest in the relationship between working memory, cognitive skills, and academic abilities. To the author's knowledge, no previous study has demonstrated significant changes in verbal abilities, nonverbal abilities, IQ composite, and academic abilities in 30 hours of intervention; this is despite insignificant measurable changes in working memory. The current research seeks to engage theologians, educators, and psychologist in a discussion on the cognitive modifiability of individuals with neurodevelopmental disorders. This study provides a format which reaches an international, multi-disciplinary audience with a holistic approach to strengthen cognitive abilities, and acknowledges the importance of spiritual, academic, and cognitive formation. These findings contribute to the precedent literature discussion in four areas: naturalistic or biblical worldview of human development, fixed or modifiable intelligence, computer training or human mediator, and working memory or cognitive functions.

Naturalistic or Biblical Worldview of Human Development

Seemingly, the naturalistic view of humanity and human development has been widely accepted. Many Christian educators have come to accept the theories of human development embraced by the American educational system that discount spirituality and have a naturalist worldview rather than a biblical view of human development. Developmental theories have informed our perspectives, expectations, and limitations of

learners who have intellectual, behavioral, and physical challenges. According to Brett Webb Mitchell,

> Human developmental theories are not theologically neutral. For according to these theories we are not first and foremost God's children, created in God's image. Instead, we become the sum of our many divided and disparate developmental categories. Depending on the developmental theory used, each theory is inextricably connected to certain assumptions both about the self, our relationship with one another and the means by which we grow, and about the particular ends to which we are growing. These assumptions may be contrary to, if not antagonistic toward, the practices of the church.[13]

Jean Piaget's theory of development and his naturalistic views, which have significantly impacted educators understanding of human development, have been virtually unchallenged.[14] Upon speaking to theologians, educators, and psychologists, the author of this study found while Piaget's name and theories are renowned and accepted, the names of John Amos Comenius and Reuven Feuerstein are virtually unknown.

In the 1600's, John Amos Comenius, the father of modern education and a reformed theologian, developed a system of progressive instruction according to the stage of human development a learner had reached, which was a precursor to developmental psychology. Piaget states, "Comenius was the first to conceive a full-scale science of education."[15] While Piaget had great admiration for Comenius' work, he dismissed and misunderstood Comenius' biblical worldview. According to Jean Piaget, Comenius' seventeenth century views on metaphysics and theology as presented in *The Great*

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[13]Brett Webb Mitchell, "Leaving Development Behind and Beginning Our Pilgrimage," in *Care for the Soul*, ed. Mark R. McMinn and Timothy R. Phillips (Downers Grove, IL: IVP Academic, 2001), 81.

[14]Jonathan H. Kim, "Intellectual Development and Christian Formation," in *Christian Formation: Integrating Theology and Human Development,* ed. James R. Estep and Jonathan H. Kim (Nashville: B and H Publishing Group, 2011), 66.

[15]Jean Piaget, "The Significance of John Amos Comenius at the Present Time," in *John Amos Comenius on Education*, ed. Jean Piaget (New York: Teachers College Press, 1967), 1–3.

Didactic were not relevant in the twentieth century.[16]

In *The Great Didactic,* Comenius presents the first principles of human development and instruction as he brings theology, education, and human development together. Comenius admonishes the reader to, "Know thyself, O man and Know Me, Me the source of eternity, of wisdom and of grace; thyself, My creation, My likeness, My delight."[17] As man is the center of God's creation, Comenius believes, "Man is naturally capable of acquiring a knowledge of all things, since, in the first place he is the image of God."[18] Comenius' insights into the potential and unlimited capacity of the human mind truly was hundreds of years before his time, as well as the scientific discovery of neuroplasticity as he states, "The mind; neither in heaven nor anywhere outside heaven, can a boundary be fixed."[19]

Reuven Feuerstein, simultaneously a clinical and cognitive psychologist, a theist and devout orthodox Jew, believed that we are created in the image of God. While he did not always insert his strong religious beliefs in his general writings, they were the foundation for his theories of cognitive development as he would refer to these beliefs in his formal lectures and professional training.[20] He studied the Bible throughout his life,

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[16]Piaget, "The Significance of John Amos Comenius at the Present Time," 4.

[17]*The Great Didactic of John Amos Comenius*, trans. M. W. Keatinge (1896; repr., London: Forgotten Books, 2012), 25.

[18]Ibid., 41.

[19]Ibid., 42.

[20]Feuerstein, *Biblical and Talmudic Antecedents*, 6. See also Louis H. Falik and Refael S. Feuerstein, preface to *Changing Minds and Brains* (New York: Teachers College Press, 2015), xxiii–iv. According to Falik and Feuerstein, regarding the last work by Reuven Feuerstein, one objective of this book was, "To give voice to the influence of Judaic culture in the formation and development of Professor Feuerstein's lifework. He was deeply religious, has throughout his life brought his knowledge and familiarity with the philosophy and practice of his Judaism into his educational and psychological theories and his practices, and devoted his life to the transmission of his culture, again to benefit humankind."

and credited the daily discussions of Scripture with his father with developing his cognitive abilities.[21] To reiterate his theistic worldview, he stated, "The individual is asked to act in the image of [God] as is stated: [God] made man in his image."[22]

The current research brings the theist views and theories of Comenius and Feuerstein to the discussion on human development and the importance of one's worldview when viewing individuals. An integration of the biblical view of humanity as created as the *imago Dei* imparts immeasurable worth to all human life regardless of gender, ethnicity, age, or cognitive abilities. Christian theologians, educators and psychologist can embrace the theist views of human development of Comenius, the father of modern education, and Feuerstein, a clinical and cognitive psychologist who spent his life working with individuals with NLD to reach their full potential.[23]

The *EMCDC* used in the current study is based on a biblical worldview of human development furthering the theistic perspectives of Comenius and Feuerstein, which see all individuals as created as the *imago Dei*; these theories allow us to see everyone through the lens of a biblical worldview rather than a naturalistic worldview. Christian educators, theologians, and psychologist can use *EMCDC* in their schools, churches, and private practice which will impact curricula, admission policies, and ministries in schools and churches. The findings from the current research support

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[21]Reuven Feuerstein and Ann Lewin-Benham, *What Learning Looks Like: Mediated Learning in Theory and Practice, K-6* (New York: Teachers College Press, 2012), 5–6.

[22]Shmuel Feuerstein, *Biblical and Talmudic Antecedents of Mediated Learning Experience Theory: Educational and Didactic implication for Inter-Generational Cultural Transmission* (Jerusalem: ICEP Publications, 2002), 5.

[23]Ibid.,52.

viewing individuals with a NLD from a biblical worldview whose cognitive abilities can be increased.

Fixed or Modifiable Intelligence

The belief that cognitive abilities are fixed has been prevalent in the United States for many years.[24] An individual's intellectual ability has been measured by his or her "intelligence quotient" (IQ).[25] Proponents of this *fixist* point of view believe that change in functioning and behavior cannot be made beyond a certain level.[26] This belief system led many to view learners with neurodevelopmental learning disorders as having a fixed limit to their cognitive abilities. However, over the last two decades the field of neuroscience has used non-invasive technologies, such as the functional magnetic resonance image (fMRI) and positron emission tomography (PET), to show the plasticity of the brain, or *neuroplasticity*, which shows the brain's ability to heal, grow, and change.[27] These imaging techniques show brain activity during development and learning. According to Oon-Seng Tan and Alice Seok-Hoon Seng, "It is now increasingly recognized that the brain is not a static structure and is in fact a modifiable system that changes its physical and functional architecture in response to its complex interaction with its internal processes and the environment."[28]

The first program to increase intellectual performance for those with neurodevelopmental learning disorders was Feuerstein's Instrumental Enrichment (FIE)

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[24]Robert Sternberg, foreword to *Cognitive Modifiability in Learning and Assessment,* ed. Oon-Seng Tan and Alice Seok-Hoon Seng (Singapore: Cengage Learning, 2008), vii.

[25]Vikram Patel, Lisa Aronson, and Gauri Divan, *A School Counsellor Casebook* (Manipal, India: Byword Books, 2013), 50.

[26]Robert J. Sternberg, "How Can We Teach Intelligence?" in *Educational Leadership* September 42, no. 1 (1984): 38.

[27]Miriam Boleyn-Fitzgerald, introduction to *Pictures of the Mind*, xi.

[28]Tan and Seng, preface to *Cognitive Modifiability in Learning and Assessment*, ix.

standard and basic programs developed more than fifty years ago by Reuven Feuerstein.[29] Since the 1950s, Feuerstein has been a critic of the standard views of intelligence. Feuerstein believed that intelligence was changeable and modifiable regardless of age, neurodevelopmental conditions, genetics, and developmental disabilities.[30] He also disagreed with the accepted concept of the *critical period* or *critical age,* which states that if a person has not reached a particular function by a certain age, he or she no longer has the ability to learn that skill.[31]

Feuerstein's theory is known as Structural Cognitive Modifiability (SCM). His theory of human development has three basic ideas:

1. Three forces shape human beings: environment, human biology, and mediation.

2. Temporary states determine behavior: How someone behaves—namely emotional, intellectual, and even habitually learned activities—represents a temporary state, not a permanent trait. This means that intelligence is adaptive. In other words, intelligence can change; it is not fixed once and for all.

3. The brain is plastic: because all behaviors are open and developing, the brain can generate new structures through a combination of external and internal factors.[32]

Feuerstein insisted that human cognitive abilities can be changed regardless of heredity, genetic disorder, chromosomal disorders, or a person's age, even if the neuro-developmental condition is generally considered irrevocable and irreparable.[33] The Feuerstein Institute has been conducting research for the last five decades.[34] These

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[29]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 27.

[30]Ibid., 8–9.

[31]Ibid.

[32]Reuven Feuerstein et al., *The Feuerstein Instrumental Enrichment Program (*Jerusalem: ICELP Publications, 2006), 25–27.

[33]Reuven Feuerstein and Ann Lewin-Benham, *What Learning Looks Like: Mediated Learning in Theory and Practice, K-6* (New York: Teachers College Press, 2012), 30.

[34]Tan and Seng, *Cognitive Modifiability,* 4–9.

studies have encompassed many types of student populations.[35] Feuerstein begins his discussion of the two components of modifiable intelligence, the intellect and the emotion, with an unusual perspective, an expression of *faith*:

> This word, *faith*, is used despite the fact that from a position of *science* one has the inclination and training to divest oneself completely from such an "unscientific" term. But the point we wish to emphasize is that in the beginning there must be a *need*- a need that will generate the belief in human modifiability. I must have the need to have my students and those with who I am engaged reach higher potentials of functioning. This need energizes me to act and motivates my faith (belief) that there are positive, effective, and meaningful alternatives to be found, to fight for, and to bring this faith into being. I believe that the student is a modifiable being who is capable of change and capable of changing according to his or her will and decisions. Human beings' modifiability differentiates them from other creatures and, according to the Rabbinic Midrash, 'even from the angels.' Herein lies the main uniqueness of human beings.[36]

An individual case study was done with the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*)[37] from 2011-2015 with a learner with a NLD, namely Down syndrome.[38] In September 2011, Marie's[39] parents contacted Brown to discuss using *EMCDC* to strengthen Marie's cognitive abilities; this included visual and auditory processing speed, comprehension, working memory**,** long term memory, and reasoning skills. According to her parents, despite all the support from Marie's teachers, occupational therapist, speech therapist, special education teacher, and principal in third grade, her Measures of Academic Progress (MAP) scores—yearly academic tests that measure student growth from semester to semester—stayed stagnant for a full year. In the fall semester of her fourth grade year the first MAP scores again showed no growth. Brown reviewed the academic and psychological testing showing an intellectual

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[35]Feuerstein et al., *Feuerstein Instrumental Enrichment Program*, 419–59.

[36]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 6.

[37]Brown developed *EMCDC*, which includes a teacher workbook, student workbook, and instructional DVDs; it is intended for use in regular or special education classrooms, churches, or home environments by teachers, therapists, and parents.

[38]Brown, "Equipping Minds for Christian Education," 147–68.

[39]The student's name has been changed to protect her privacy.

disability with deficits in processing, working memory, comprehension, and perceptual reasoning; she then agreed to begin working with Marie using *EMCDC*.

With the support of the school system, Brown worked with Marie an hour of every school day for the next twelve weeks. At the end of nine weeks, the principal enthusiastically reported that Marie had increased 20 points in reading, 11 points in math, 25 points in science, and 17 points in language arts. These gains were unprecedented, as students typically increase 3–5 points.

Until this time, Marie had made minimal progress and her academic test scores had remained static from third to fourth grade. The change in these scores had been achieved over the nine-week period through one-on-one cognitive developmental exercises for enhancing processing, working memory, comprehension, and reasoning; this was divorced from academic content. Previously, she had received the standard interventions, which included remediation of content, learning strategies, and accommodations. These may have short-term benefits, but were not targeting the underlying cognitive deficits in processing and working memory, which would increase her cognitive abilities.

Marie's progress is significant for those who still believe that measureable intelligence is due primarily to nature or one's genetic factors, and only minimally due to nurture or environmental factors which holds to a limited potential for change.[40] Since Marie has an intellectual disability and Down syndrome, many educators believe these disorders limit her ability for significant academic gains.[41] However, Marie's

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[40]R. Herrnstein and C. Murray, *The Bell Curve: Intelligence and Class Structure in American Life* (New York: The Free Press, 1994), 22–23.

[41]Carolyn Mervis, interview by author, Louisville, KY, May 14, 2012. Mervis stated that in her research with students with Down Syndrome, she was not aware of any case where cognitive developmental exercises had generalized to academics in a nine-week period. Mervis performed a full cognitive assessment on Marie. She stated that the gains in processing and working memory were greater than she had ever seen; Carolyn Mervis, e-mail to the author, February 9, 2015. Marie and seven other students with Down Syndrome were asked to participate in a three-year pilot study with *EMCDC* with the University of Louisville Department of Psychological and Brain Sciences in the summer of 2011. The pilot study was not completed according to a correspondence with Mervin due to other research commitments

improvement implies that cognitive developmental exercises do have far transfer effects to academic achievement for learners who have an intellectual developmental disorder. Over the next four years the MAP test results demonstrated significant gains in academic abilities.[42] These results with Marie were foundational to the current study with *EMCDC*.

The results of the current research with *EMCDC* support the research done with FIE by Alex Kozulin and colleagues who conducted a study with 104 learners from Canada, Belgium, Italy, and Israel who had neurodevelopmental disabilities, cerebral palsy, genetically-based intellectual impairments, autism or ADHD. The FIE Basic program that is designed for young learners was used over thirty to forty-five weeks. The research subjects showed statistically significant improvements in the WISC-R subtests of similarities, picture completion, and picture arrangement, as well as on Raven's Colored Matrices.[43]

A significant difference between the research by Kozulin and colleagues and the current study with *EMCDC* is the length of time needed before seeing gains in cognitive and academic abilities. According to Kozulin, the academic coordinator at the Feuerstein Institute, research studies with FIE are a minimum of 60 hours.[44] The *EMCDC* study was done over 7 weeks for 30-hours and showed statistically significant improvements in nonverbal abilities, verbal abilities, IQ composite, and science scores. The current research extends the research of the Feuerstein Institute.

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within the department.

[42]It should be noted that while Marie has Down syndrome, the only accommodations she received on MAP testing was extended time and having a reader for math, science, and language. She read the reading assessments herself.

[43]Alex Kozulin et al., "Cognitive Modifiability of Children with Developmental Disabilities: A Multicenter Study using Feuerstein's Instrumental Enrichment–Basic program," *Research in Developmental Disabilities* 31 (2010): 551–59.

[44]Alex Kozulin, e-mail to author, August 11, 2016.

Computer or Human Mediator

In recent years the majority of research studies in peer reviewed journals have utilized computer software programs to enhance cognitive skills with a focus on working memory training.[45] An alternative approach absent in the current literature on working memory is the use of a human mediator. While the use of technology in the classroom is prolific, it is impersonal and has not been proven to be more effective than a human mediator. In 2013, *Developmental Psychology* ran an article evaluating the claims of computer-based cognitive skill programs by Hulme and Melby-Lervag, who conducted a systematic meta-analysis review of the existing studies.[46] Hulme and Melby-Lervag concluded,

> Currently available working memory training programs have been investigated in a wide range of studies involving typically developing children, children with cognitive impairments (particularly ADHD), and healthy adults. Our meta-analyses show clearly that these training programs give only near-transfer effects, and there is no convincing evidence that even such near-transfer effects are durable. The absence of transfer to tasks that are unlike the training tasks shows that there is no evidence these programs are suitable as methods of treatment for children with developmental cognitive disorders or as ways of effecting general improvements in adults' or children's cognitive skills or scholastic attainments.[47]

However, the Feuerstein Institute has conducted research with FIE that confirms cognitive abilities can be modified demonstrating far transfer effects and generalized to academics for many years.[48] A crucial difference with FIE and the computer programs is the use of a human mediator. Mediation is an interaction in which a human mediator who possesses knowledge intends to convey a particular meaning or skill and encourages the

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[45]Kenneth J. Kohutek, "The Children's Cognitive Enhancement Program: A Pilot Study," *Journal of Scholastic Inquiry: Education* 1 (October 2014): 166–67.

[46]Melby-Lervag and Hulme, "Is Working Memory Training Effective?," 270–91. See also H. L. Roediger and M. A. Pyc, "Inexpensive Techniques to Improve Education: Applying Cognitive Psychology to Enhance Educational Practice," *Journal of Applied Research in Memory and Cognition* 1 (2012): 242–48.

[47]Melby-Lervag and Hulme, "Is Working Memory Training Effective?," 283.

[48]Tan and Seng, *Cognitive Modifiability in Learning,* 4–9.

child to transcend, that is, to relate the meaning to some other thought or experience. Mediation is intended to help children expand their cognitive capacity, especially when ideas are new or challenging. Feuerstein believes a human mediator is needed, or "stimulus-human-organism-human-response (S-H-O-H-R)," allowing the mediator to take the learner beyond the natural limitations to reaching his or her full cognitive potential. Feuerstein sees the human mediator as crucial for a learner's development.[49] Feuerstein's theory of Mediated Learning Experience (MLE) initially grew as part of Feuerstein's theory of Structural Cognitive Modifiability (SCM).[50]

Educators who implement mediation into their teaching realize that students with NLD can learn and are modifiable.[51] According to Brian Boyd, "Feuerstein believed that when someone presents himself or herself as unable to understand something, one does not make the assumption that he or she is unintelligent. Rather, it is assumed that the person's intelligence is lying dormant, and the process of mediation by a teacher allows that intelligence—that latent intelligence—to come to the surface."[52]

The concept of having a mediator to assist and teach those who are weaker is rooted in Scripture, as well as in both the Christian and Jewish communities. God says of Abraham, "For I have known him, in order that he may command his children and his household after him, that they keep the way of the Lord, to do righteousness and justice, that the Lord may bring to Abraham what He has spoken to him" (Gen 18:19). This meaningful and intentional approach is in direct contrast to the use of an impersonal

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[49]Feuerstein, Feuerstein, and Falik, *Beyond Smarter,* 27.

[50]Feuerstein and Lewin-Benham, *What Learning Looks Like*, 27.

[51]Feuerstein, Falik, and Feuerstein, *Changing Minds*, 7.

[52]Brian Boyd, "Intelligence is Not Fixed," The Journey to Excellence website, Windows Media Player video file (August 31, 2007), accessed May 7, 2014, http://journeytoexcellence.org.uk/videos/expertspeakers/intelligenceisnotfixedbrianboyd.asp.

computer program, as unmediated exposure to stimulus is meaningless for those with neurodevelopmental disorders. According to Shmuel Feuerstein, "Intensive exposure to mediational experience makes meaningful and pervasive changes in the individual's cognitive structures."[53] The theistic foundations to MLE are found in *Biblical and Talmudic Antecedents of Mediated Learning Experience and Theory*, written by Shmuel Feuerstein, brother and colleague of Reuven Feuerstein. Shmuel Feuerstein expounds on the biblical foundations of the theory of Mediated Learning. He shows the relationships between events, religious precepts, and conduct with a modern psycho-educational theory. Shmuel Feuerstein reminds the reader that there is a strong emphasis on the process of identification in Judaism, and mediation is the means through which a sense of identity is instilled.[54] Shmuel Feuerstein states,

> There are a whole series of qualities and attributes related to God which the human being learns to aspire to. The individual is asked to act in the image of God as is stated: God made man in his image. This image becomes the rationale for identification with characteristics that are attributed to the image of God. Identification is not only an emotional, volitional or motivational act but is probably one of the first and strongest requirements placed on the Jewish person.[55]

Shmuel Feuerstein also agreed with Comenius on two matters. First, that as God's creation, all individuals, regardless of abilities should be treated with human dignity. As the Prophet Malachi states, **"**Have we not all one father? Hath not one God created us" (Mal 2:10)? Secondly, he believes that mediation stretches the mind and the

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[53]Shmuel Feuerstein, *Biblical and Talmudic Antecedents of Mediated Learning Experience Theory*, 22. Kozulin said, "Shmuel Feuerstein is Reuven Feuerstein's younger brother. Shmuel worked for many years in the Ministry of Education as a supervisor of the Biblical studies in Israeli state-religious schools. At a rather advanced age he received his PhD (see his book) and started teaching at Bar Ilan University and Ashkelon College. As far as I know Shmuel and Reuven started collaborating professionally only at the time of Shmuel's doctoral research." Alex Kozulin, e-mail to the author, December 31, 2015.

[54]Feuerstein, *Biblical and Talmudic Antecedents*, 11.

[55]Ibid., 11–12.

cognitive capacities of an individual to optimal limits and reasoning capacity. Shmuel Feuerstein states,

> Developing each individual's mental capacities is an end in itself but it is also an important religious value. Each individual is endowed by God with capacities which must be developed to the fullest in order to fulfil God's will and place one's abilities in the service of God.[56]

Furthermore, Comenius reminds the reader that God is not a respecter of persons, and no one should be excluded because of their intellect. He believed that those with weak intellects need assistance by a mediator: "We do not know to what uses divine providence has destined this or that man; but this is certain, that out of the poorest, the most abject, and the most obscure, He has produced instruments for His glory."[57]

The *Equipping Minds Cognitive Development Curriculum* (*EMCDC)* is a method of cognitive skill development which uses a human mediator and is based on the theory of Structural Cognitive Modifiability (SCM), Mediated Learning Experience (MLE), and a biblical worldview of human development. The success of the research with *EMCDC* supports the use of a human mediator, which is rooted in Scripture and Feuerstein's theory of Mediated Learning Experience (MLE), and affirms that cognitive skills can be developed in the classroom or clinical setting through a human mediator rather than a computer program.[58]

Working Memory or Cognitive Functions

While man has been fascinated with memory and cognitive abilities for thousands of years, it was the scientific study of memory that led to the current interest in understanding the consequences of deficits in working memory capacity and learning

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[56]Feuerstein, *Biblical and Talmudic Antecedents*, 26.

[57]Ibid., 66.

[58]Ibid.

disorders. Over the last twenty years, research on working memory found reliable correlations between working memory span and several other measures of cognitive function, intelligence, and performance in school.[59] Recent studies on individual differences in mathematical abilities show that aspects of working memory contribute to early arithmetic performance.[60] Further studies examine the relationship between working memory, reading, and comprehension.[61] The key to intelligence is being able to put those facts together, prioritize the information, and do something constructive with it. Working memory is the skill that gives an individual the advantage of managing all this information and is a stronger indicator of a learner's academic and personal potential than an IQ test.[62]

Working memory deficits impact all learners with a NLD.[63] According to the *DSM*-5, "The disorders are characterized by developmental deficits that produce impairments of personal, social, academic, or occupational functioning. The range of developmental deficits varies from very specific limitations of learning or control of executive functions to global impairments of social skills or intelligence."[64] This was the

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[59]Alloway, *Improving Working Memory*, 10–14; Jaeggi et al., "Improving Fluid Intelligence with Training on Working Memory," 6829–33.

[60]Kimberly P. Raghubar, Marcia A. Barnes, and Steven A. Hecht, "Working Memory and Mathematics: A Review of Developmental, Individual Difference, and Cognitive Approaches," *Learning and Individual Differences* 20 (2010): 110–22.

[61]Barbara Carretti et al., "The Role of Working Memory in Explaining the Performance of Individuals with Specific Reading Comprehension Difficulties: A Meta-Analysis," *Learning and Individual Differences* 19, no. 2 (2009): 246–51. See also Rune Andreassen and Ivar Braten, "Examining the Prediction of Reading Comprehension on Different Multiple Choice Tests," *Journal of Research in Reading* 33, no. 3 (2010): 263–83.

[62]Alloway and Alloway, *Working Memory Advantage*, 16. See also Tracy Packiam Alloway and Ross Alloway, "Investigating the Predictive Roles of Working Memory and IQ in Academic Attainment," *Journal of Experimental Child Psychology* 106 (2010): 27.

[63]Tracy Alloway, "Introduction," in *Working Memory and Neurodevelopmental Disorders,* ed. T. P. Alloway and S. E. Gathercole (London: Psychology Press. 2006), 1–2.

[64]*Diagnostic and Statistical Manual of Mental Disorders*, 31.

basis for Brown's presupposition of the causative effect of working memory on verbal and nonverbal abilities, IQ composite, and academic abilities, which proved to be wrong.

The current study contradicts the idea that working memory is a stronger indicator of a learner's academic and personal potential than an IQ test and the research of Alloway et al. which demonstrated gains in working memory which generalized to verbal, nonverbal, and spelling in 8 weeks. The current research demonstrated that working memory training does not seem to have a causative effect in relationship to verbal, nonverbal, and academic abilities when using *EMCDC* for 30 hours of intervention and removes this limitation for learners with a SLD.[65] This finding adds to the importance of Feuerstein's emphasis on deficient cognitive functions rather than deficient working memory alone.

Moreover, the findings from the current study are consistent with Feuerstein's research that training cognitive functions can have significant impacts on cognitive and academic abilities**.** The *Equipping Minds Cognitive Development Curriculum* (*EMCDC*) is a method of cognitive skill development in the areas of processing, working memory, comprehension, and reasoning, which are based on correcting the deficient cognitive functions as described by Feuerstein.

Feuerstein examines the cognitive function underlying intelligence and what is going on in the learner's mind. Feuerstein defines cognitive functions as "thinking abilities" that can be taught, learned, and developed.[66] Feuerstein has categorized the cognitive functions according to the three major phases of the mental act: input, elaboration, and output. Although artificially separated into three phases, cognitive functions do not necessarily occur separately in life. However, the subdivision is useful to analyze and describe thinking as well as to determine what factors might negatively

[65]Alloway, "Computerized Working Memory Training," 632–38.

[66]Feuerstein et al., *Feuerstein Instrumental Enrichment Program*, 135.

affect thinking.[67] Teachers and parents can use this model to better understand and help the learner who is experiencing difficulties with a particular task. By having a working knowledge of the cognitive functions, teachers[68] can differentiate between errors due to a lack of knowledge or from a deficient cognitive function.[69] For example, if the learner fails in the task of classification, it is not enough to comment on the learner's poor intelligence or inability to classify, but rather the underlying causes of the difficulty (which can be found in one of the three phases of thinking) should be sought. The inability to classify, for instance, may be due to underlying underdeveloped functions, such as imprecise data gathering at the input phase or poor communication skills at the output phase. A detailed analysis of a learner's cognitive functions requires an in-depth understanding of the three phases of the mental act.[70]

Deficient Cognitive Functions and Corrections Needed: **Input Level**

The following list identifies and describes the deficient cognitive functions that Feuerstein's Instrumental Enrichment (FIE) seeks to correct in learners with neurodevelopmental learning disorders and learning disabilities. Understanding the degree to which the learner is affected directs the mediation process for cognitive modifiability.[71]

1. Blurred and sweeping perception of essential information occurs. The learner struggles to gather the correct information. Correction: The learner learns to focus and perceive the data through his senses.

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[67]Feuerstein et al., *Feuerstein Instrumental Enrichment Program*, 135.

[68]Feuerstein, Falik, and Feuerstein, *Changing Minds and Brains*, 5. Reuven Feuerstein and his co-authors state, "All teaching is not mediation; but all mediation is teaching."

[69]Feuerstein et al., *Feuerstein Instrumental Enrichment Program*, 131–33.

[70]Mandia Mentis et al., *Bridging Learning: Unlocking Cognitive Potential In and Out of the Classroom* (Thousand Oaks, CA: Corwin, 2009), 115.

[71]Feuerstein et al., *Feuerstein Instrumental Enrichment Program*, 136.

2. Difficulty in temporal and spatial orientation occurs. The learner lacks the ability to organize information realistically and to describe events in terms of where and when they occur. Correction: The learner learns the critical concepts of right, left, front, and back to know where they are positioned in space.

3. Deficient skills in precision and accuracy are present. Correction: The learner collects the correct information.

4. Inability to identify an object when there is a change in size, shape, quantity, or orientation, though it is the same object. Correction: The learner is able to decide what characteristics stay the same even when change happens.

5. Lack of capacity for considering two or more sources of information at once is present. This is reflected in dealing with data in a piecemeal fashion rather than as a unit of organized facts. Correction: The learner's able to keep two ideas in his mind at the same time and compare them.

6. Impulsive and unplanned exploratory behavior is present. Correction: The learner is able to systematically approach new information and objects.[72]

Deficient Cognitive Functions and Corrections Needed: **Elaboration Level**

1. Lack of ability to recognize the existence and definition of an actual problem. Correction: The learner can define the problem.

2. Inability to select relevant vs. non-relevant cues or data in defining a problem is present. Correction: The learner can recognize what is relevant to the problem and what can be ignored.

3. Difficulty in comparative behavior is present. This may be due to slow processing and inability to make comparisons between two or more things. Correction: The learner can see the similarities and differences between two things.

4. A narrow mental field is present. There is an inability to combine, group, and coordinate information. Correction: The learner can recall and use several pieces of information.

5. The projection of virtual relationships is impaired. The ability to perceive the relationship between events is difficult. Correction: The learner can understand relationships, apply conceptual labels, and categorize objects. He understands the main idea.

6. The absence of or need for logical evidence, inferential-hypothetical thinking, and

[72]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 140–53.

hypothesis development occurs. Correction: The learner is able to use hypothetical thinking to test a hypothesis. He can see cause-and-effect relationships and use logical evidence.

7. Inability to visualize and create mental images is present. Correction: The learner is able to move away from concrete thinking to visualization.

8. Difficulty defining goals, planning behavior, and taking steps in problem solving occurs. Correction: The learner is able to form problem-solving strategies, make a plan, state the steps, and provide the reasons.[73]

Deficient Cognitive Functions and Corrections Needed: **Output Level**

1. Egocentric communicational modalities are present. It is difficult for the learner to relate to others and to see things from another's perspective. Correction: The learner is able to consider another person's point of view.

2. Lack of ability to repeat an attempt after a failure or blocking is present. Correction: The learner is able to persevere and overcome blocking.

3. Difficulty in projecting virtual relationships. Correction: The student is able to see virtual relationships such as two women can be cousins or four dots can be a square.

4. Use of trial-and-error responses, which leads to failure to learn from previous attempts, is present. Correction: The learner is able to stop and think through a plan of action.

5. Lack of, or impaired tools for communicating adequately elaborated responses. Correction: The students is able to give a thoughtful response.

6. Lack of, or impaired, need for precision and accuracy in communicating one's responses. Correction: The student is able to be precise and accurate when communicating.

7. Lack of self-control, impulsive, or acting-out behavior is demonstrated. Correction: The student exhibits self-control in speech and behavior.

8. Unable to visually transport information from one place to another, or unable to see the missing part. Correction: The learner is able to see the relationship between things that are not present.[74]

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[73]Feuerstein et al., *Feuerstein Instrumental Enrichment Program,* 153–76.

[74]Ibid., 178–83.

Feuerstein has sought to identify and correct these deficits to enable students to reach their full cognitive potential, as well as to increase their internal motivation and personal confidence. By using mediation, these deficient functions can be corrected, formed and modified in significant ways.[75] *EMCDC* seeks to correct these deficient cognitive functions through the cognitive developmental exercises implemented in the current research study.

Additionally, this present study demonstrated that it possible to use *EMCDC* to raise the cognitive abilities of learners to an extent that has previously not been linked to learners with these disorders in 30 hours over 7 weeks. The current research found that training in working memory, processing, comprehension, and reasoning with *EMCDC* does provide convincing evidence to the generalization of verbal abilities, nonverbal abilities, and IQ composite. Similarly, far transfer effects to academic abilities in science were substantiated with significant and gains using *EMCDC*. The results support the theories of MLE and SCM and the research of Feuerstein. *EMCDC*'s use of a human mediator and cognitive developmental exercises, which are based on a biblical worldview and Feuerstein's cognitive functions, have a greater impact than working memory training by a computer program alone.

Recommendations for Practice and Research Applications

The evidence for cognitive modifiability in learners with SLD based on Feuerstein's theories of SCM and MLE should be embraced by Christian educators. We should no longer accept a naturalistic worldview based on biological determinism, which discounts spirituality and which views learners with neurodevelopmental leaning disorders as having a fixed limit to their cognitive abilities. However, we should align

[75]Feuerstein, Feuerstein, and Falik, *Beyond Smarter*, 83–84.

with the theistic perspective of Feuerstein which sees all individuals as created as the *imago Dei* and in need of a human mediator. These theories direct and inform our religious and academic curricula, the learners we admit to our institutions, and our views of the cognitive abilities and potential of these learners.

This research demonstrates that cognitive abilities in verbal and nonverbal abilities can be increased and generalized to academics using *EMCDC*. Educational settings which view cognitive development as a goal in itself and view the teacher as a mediator who invites the learner to identify a problem, to analyze it, to use inductive thinking processes to develop a strategy for its solution—and connect it to other knowledge networks—can use *EMCDC* in their classrooms. The implications for the church, Christian school practitioners, Christian higher education practitioners, Christian academicians and professionals, homeschool parents, adoption and foster care parents, and missionaries are substantial since intelligence can be developed when a mediator teaches and trains a learner.

The following list is a summary of the recommendations for practice and research application derived from the findings of this study.

1. Research has found that families with disabilities who participate in a faith community and spiritual formation have a higher quality of life.[76] *EMCDC* can benefit local church leaders as a resource for developing a special-needs ministry in the church and providing an after school or summer program for children and adults

[76]Melinda Jones Ault, Belva Collins, and Erik Carter, "Congregational Participation and Supports for Children and Adults with Disabilities: Parent Perceptions," *Intellectual and Developmental Disabilities* 51, no. 1 (2013): 48–61. The parents who completed the survey were primarily Protestant or Roman Catholic (89.5%) and 97.6% reported their faith was somewhat important to them. The authors found that 55.8% of the families had kept their child from participating in a religious activity because support was not provided, 46.6% had refrained from participating in religious activity because their child was not welcomed, and 32.3% had changed their place of worship because their child was not included or welcomed. The majority of these parents were not satisfied with the levels of support provided by their faith communities with only 42.5% describing their congregations as *supportive*, 41.1% describing their congregations as *sometimes supportive*, and 12.7% indicating they were *not supportive*. They found 67.3% of parents responding to the survey wanted additional support so their children could participate in regular activities. The five activities the child participated were religious services (85.3%), religious education (60.8%), recreational activities (24.8%), volunteer work (16.2%), and small group meetings (14.2%). The majority of the children participated in regular activities with (21%) not participating.

to integrate spiritual formation and cognitive formation. There are approximately 54 million people in the U.S. that are affected by disability, with estimates of 80 percent who are un-reached and do not attend a Christ-honoring church. Yet, less than 10 percent of the churches in the U.S. have an intentional disability ministry and outreach.[77]

2. Feuerstein and Comenius allowed their theistic beliefs to deeply impact their education practices. They agree with the church that every individual is created as the *Imago Dei.* The compassion of the church is seen through loving others and sharing the gospel. This should also impact the church's commitment to develop the cognitive capacity in each individual with a disability. The cognitive formation will strengthen the spiritual formation to use one's abilities in service to God and for His glory.

3. Christian school practitioners can understand the benefit of mediated learning and the *EMCDC* cognitive developmental exercises. The combination of cognitive developmental exercises and curricular studies should result in significant advancement of both cognitive and domain-specific skills for all learners. The Christian school will no longer need to refer parents to public schools but will be able to include more students with NLD in the Christian school setting.

4. Christian higher education administrators, practitioners, and student service professionals who serve and teach students with NLD and those with undiagnosed learning struggles can use *EMCDC*. By addressing the underlying deficits in cognitive abilities an increase in student's academic satisfaction may result thereby increasing student retention and graduation rates. As the number of adult learners is increasing in higher education, it is important to continue to engage in stimulating learning activities during adulthood to manage the demands on cognitive abilities.

5. Brown has been training public school teachers and interventionists in individual schools, at the district level, and at the annual Kentucky Association of School Councils conference in 2011, 2013, 2015, and 2016. There are currently over twenty Kentucky public school districts who are using *EMCDC*. Cognitive development training with *EMCDC* could be used in the course *Teaching Exceptional Learners* in the Teacher Education Program at Boyce College.

6. As the father of modern education and developmental psychology, Comenius brings theology, education, and the social sciences together. Christian practitioners in these fields should read the *Great Didactic* and understand the foundation of their profession. From a practical application, Christian academicians and professionals in the fields of education, cognitive psychology, educational psychology, child and adolescent psychiatry, human development, social work, occupational therapy, and speech-language pathology who work with learners with NLD can use *EMCDC* in their practice.

7. Homeschool parents can use the *EMCDC* with their children to lay a strong cognitive foundation. Parents are commanded in Scripture to teach their children.

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[77]Joni Tada, *The Father's House*, DVD (Agoura Hills, CA: Joni and Friends), accessed June 22, 2015. https://beta.rightnowmediaatwork.org/Content/Series/514.

Effective teaching includes mediation. Humans were created to be relational beings and not created to live in isolation promoting individualism. The homeschool parent has a tremendous opportunity to increase their child's cognitive abilities by apply the principles of mediated learning. The Home School Legal Defense Association has over 14,000 families who subscribe to the struggling learners newsletter.[78]

8. The World Health Organization and the World Bank released a report in June 2011 stating that 15 percent of the world's population—some 785 million people—has a significant physical or intellectual disability.[79] Ninety percent of children with disabilities in developing countries do not attend school and 80 percent of people with disabilities are, in many countries, unemployed. In warfare countries there are 3 children sustaining a permanent injury for every child killed.[80] Numerous mission organizations send missionaries to these areas to reach out to their physical needs and to share the gospel.

9. While missionaries are reaching out to others, many missionaries with school aged children are discovering that their child or children have a NLD. Some missionaries chose to homeschool and others place their children in schools in the country they serve. These learning challenges can be overwhelming, and there are limited services for children with a NLD in other countries. Rather than return to the United States, these families can stay on the mission field and use *EMCDC* which can be implemented at home allowing them to continue fulfilling their calling and develop their child's cognitive abilities. *EMCDC* has mediators who can work with the families via the internet. Missionaries will also be equipped to help other learners with NLD where they serve.

   The United Kingdom's Department for International Development reports that the mortality rate is 80 percent higher for children born with disabilities, as many are abandoned and killed.[81] This has led many parents to adopt these children from around the world with disabilities. Parents who have adopted or foster children with special needs and NLD can use the *EMCDC* at home. According to Karen Purvis, adopted and foster children can bring many challenges with them including abandonment issues, neurological alternations, cognitive impairments, sensory processing deficits, and other struggles.[82] Adopted and foster children need guidance in learning to relate to others. Parents are encouraged to intentionally interact with their child and use mediated learning.[83]

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[78]Faith Berens, telephone interview with author, January 13, 2016.

[79]Joni Tada and Steve Bundy, *Beyond Suffering: A Christian View on Disability Ministry: A Cultural Adaptation*, ed. Pat Verbal (Agoura Hills, CA: Joni and Friends), 447–49, Kindle.

[80]Ibid., 798–802.

[81]Ibid., 815.

[82]Karen B. Purvis, David R. Cross, and Wendy Lyons Sunshine, *The Connected Child* (New York: McGraw-Hill, 2007), 34.

[83]Ibid., 159.

Further Research

This section provides recommendations for further research that could be done in the field of education and psychology. This study will provide a model for other researchers to examine the effects on cognitive and academic abilities using *EMCDC*. This section proposes additional studies which could expand the findings of this study.[84]

1. Using a similar design and method as conducted in this research, extending the intervention with *EMCDC* to 60 hours is recommendable, because it is the standard number of hours recommended for optimum results.

2. Using a similar design and method as conducted in this research, the study could be duplicated in both private Christian and secular schools, public schools, homeschool settings, missionary schools, higher education, and churches to include children and adults of ages with neurodevelopmental disorders.

3. Using a similar design and method as conducted in this research, a study may be done with learners with another neurodevelopmental learning disorders (NLD) such as an intellectual developmental disorder or intellectual disability (ID). This study would look at learners with Down syndrome which would expand the case study done with Marie and *EMCDC*.

4. Using a similar design and method as conducted in this research, a study may be done with learners with another neurodevelopmental learning disorder (NLD) such as communication disorders. This study would add a pre and post-test for expressive language when assessing communication disorders.

5. Using a similar design and method as conducted in this research, a study may be done with learners with another neurodevelopmental learning disorder (NLD) such as autism spectrum disorders (ASD). This study would add a pre and post-test for expressive language when assessing communication disorders.

6. Using a similar design and method as conducted in this research, a study may be done with learners with another neurodevelopmental learning disorders (NLD) such as motor disorders.

7. Using a similar design and method as conducted in this research, a working memory assessment which was administered by a mediator rather than a computer, is recommended.

8. Using a similar design and method as conducted in this research, a follow-up testing six months after the post-testing is recommended.

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[84]The daily training sheet the mediators followed for the study is found in appendix 3.

APPENDIX 1

STUDENT PARTICIPATION CONSENT FORM

Instructions

In Section 1, read the "Agreement to Participate" statement and confirm your willingness for your child to participate in this study by checking the appropriate box and entering the requested information.

In Section 2, provide responses to each of the questions by entering your child's name.

[Section 1]

Agreement to Participate

The research in which you are asked to allow your child to participate is designed to explore the impact of the *Equipping Minds Cognitive Development Curriculum* on working memory for students with a specific learning disorder diagnosis. This research is being conducted by Carol Brown for purposes of her doctoral thesis research in educational leadership at the Southern Baptist Theological Seminary. Any information you provide will be held strictly confidential, and at no time will your child's name be reported. Participation in this study is voluntary and you are free to withdraw your child from the study at any time.

☐ I agree for my child to participate ☐ I do not agree for my child to participate

Child's Name: _____Parent's Name:_____

Date: _____

[Section 2]

Procedures

If you agree for your child to be in the study, the following will occur:

1._____ (child's name) will complete a pre-assessment on both working memory and nonverbal and verbal ability. The working memory assessment will be completed on a computer and the nonverbal and verbal ability test will be completed with a qualified tester.

2._____ (child's name) if your child is selected to be in the training group by a randomized allocation, your child will receive 60 minutes of cognitive developmental training, five days a week from February 4-April 12 with the *Equipping Minds Cognitive Development Curriculum* with a certified trainer. If your child is selected to be in the active control group he will receive academic support for 60 minutes, 5 days a week for 8-12 weeks in a small group from February 4-April 12 with a teacher.

3. _____ (child's name) will complete a post-assessment on both working memory and nonverbal and verbal ability. The working memory assessment will be completed on a computer and the nonverbal and verbal ability test will be completed with a qualified tester.

4. Pseudonyms will be used on data and additionally, all identifying information will be removed or changed to maintain the confidentiality of all participants.

5. Parents may submit a written request for access to their child's scores at the end of the intervention and testing in May 2016.

RISKS AND DISCOMFORTS

Participation in this research will involve no loss of privacy and your child's records will be handled confidentially.

BENEFITS AND USES OF DATA

This study provides an opportunity for schools to learn about a cognitive development training program that may be able to enhance student learning. Carol Brown will use the information in preparation for her doctoral thesis at the Southern Baptist Theological Seminary in educational leadership. No publication or presentation of the study's findings will contain any identification of students who participated in the study.

COSTS/PAYMENT

There will be no costs to your child as a result of taking part in this study. You will receive no payment for your child's participation in this study.

QUESTIONS

You will have the opportunity to ask Carol Brown any questions about this study. Please Contact Carol via email at cbrown@equippingminds.com.

APPENDIX 2

FURTHER STATISTICAL DATA

Table A1. Group profiles and means for pre and post training assessments

	Active Control Group			Training Group		
Measures	Pre-Test M (S.E.)	Post-Test M (S.E.)	Pre-To-Post P	Pre-Test M (S.E.)	Post-Test M (S.E.)	Pre-To-Post p
Verbal WM	93.88 (8.55)	96.00 (10.30)	.2671	88.31 (11.94)	92.19 (11.50)	.0265
Visuospatial WM	101.31 (15.12)	100.25 (15.73)	.7480	93.69 (15.81)	98.00 (15.99)	.1495
Verbal Short Term Memory	94.31 (11.25)	96.75 (11.43)	.4342	89.31 (11.31)	92.50 (14.76)	.1188
Visuospatial Short Term Memory	104.50 (19.17)	101.25 (17.81)	.3542	103.13 (14.60)	104.25 (13.14)	.7224
Reading	6.156 (2.489)	6.406 (2.641)	.7508	4.131 (0.980)	5.200 (1.904)	.0399
Vocabulary	6.988 (2.496)	7.138 (2.253)	.8411	5.044 (1.663)	5.850 (2.132)	.2336
Language	6.494 (2.760)	7.575 (2.460)	.1148	4.525 (1.055)	5.694 (2.575)	.1055
Mechanics	6.038 (3.096)	5.444 (1.982)	.4624	4.500 (2.260)	5.631 (3.091)	.1549
Math	5.094 (1.912)	5.913 (2.198)	.1256	4.275 (0.904)	4.775 (2.050)	.2521
Computation	5.581 (1.843)	6.356 (2.716)	.1679	4.556 (1.301)	4.444 (1.352)	.8181
Science	6.444 (2.179)	6.463 (1.810)	.9745	4.700 (1.726)	6.138 (1.810)	.00105
Social Studies	6.081 (2.196)	6.925 (2.349)	.2268	4.763 (2.852)	5.713 (2.378)	.2345
Spelling	5.175 (2.037)	5.831 (2.178)	.1935	4.038 (1.527)	5.913 (2.459)	.00199
Verbal	101.25 (10.38)	104.19 (13.49)	.00937	94.56 (10.51)	108.00 (15.99)	.000112

Table A1 continued

Non-Verbal	104.69 (10.62)	104.19 (13.76)	.7620	100.81 (10.17)	116.00 (10.77)	.0000237
IQ Composite	103.69 (8.55)	105.06 (12.35)	.5706	97.13 (9.84)	113.94 (14.08)	.00000288

Table A2. Working memory and short term memory scores for SLD

Measures	*Active Control*			*Training Group*		
	M	$t_{(15)}$	Pre-to-Post (p)	M	$t_{(15)}$	Pre-to-Post (p)
Verbal WM	2.125	1.152	.2671	3.875	2.459	.0265 *
Visuo-Spatial WM	-1.063	-0.327	.7480	4.313	1.519	.1495
Short Term Verbal WM	2.438	-0.956	.4342	3.188	0.362	.1188
Visuo-Spatial Short Term WM	-3.250	0.804	.3542	1.125	1.655	.7224

NOTE: M = Mean of the post- minus pre-test scores; p = p-value for the two-mean t-tests for the difference in pre- and post-test scores; * = significant at the 5% level

Table A3. Regression output: effect of training
on working memory and short term memory scores for SLD

Measures	*Training B (S.E.)*	*p*	r^2
Verbal WM	1.750 (2.425)	.4761	.0171
Visuo-Spatial WM	5.375 (4.313)	.2223	.0492
Short Term Verbal WM	0.750 (3.593)	.8361	.0015
Visuo-Spatial Short Term WM	4.375 (4.606)	.3497	.0292

NOTE: B = regression coefficient of the training effect on the difference in post- minus pre-test scores; SE = standard error of the regression coefficient; p = p-value for the significance of the training on the difference in test scores; * = significant at the 5% level

APPENDIX 3

DAILY TRAINING SCHEDULE FOR GROUPS

Table A4. Daily training schedule for groups

Session #	1	2	3	4	5
Reflex Exercises at home Starfish/Finger / Wear Sound Therapy	Do every session and ask if they did the home exercises.				
Xtreme Memory	Begin with 2-3 items on 3 grid board	Continue	Continue	Continue	Continue
Tic Tac Toe	Begin with 1-9 board	Continue	Continue	Continue	Continue
Stroop Animal	Read Set 1 & 2 Circle Bear, Box Snake	Continue Add X fish Triangle cat	Continue	Continue	Continue
Blink	Sort number, Color, shape	Sort then say 1,green, star	Teach game	Continue	Continue
Spot It	Use a constant card “I see 2 blue dolphins”	Continue	Continue	Continue	Continue
Set				Sort color, shape Number	
Qwitch					
Arrows	Left/ Right	Continue	Continue	Continue	Continue

Table A4 continued

Stare Card					
Number Hunt 1-5		Green on 1, Blue 2	Circle 1, X 2 Review colors	G-1, B-2, R-3 Circle 1,X-2 box 3	Add Y-4,B-5 line under 4
Number Hunt 1-9					
Presidents		1-4 Discuss pictures	1-4	1-6	1-6
Make a List	60 seconds to name animals		Name sports		Name animals
Session #	6	7	8	9	10
Reflex Exercises at home Starfish/Finger / Wear Sound Therapy	Do every session and ask if they did the home exercises.				
Xtreme Memory	Continue adding	Continue	Continue	Continue	Continue
Tic Tac Toe	1-9 with cubes	Continue	Continue	Continue	Continue
Stroop Animal	Continue	Continue	Continue	Continue	Continue
Blink	Continue	Continue	Continue	Continue	Continue
Spot It	Continue	Continue	Continue	Continue	Continue
Set	Solids	Continue	Continue Strips	Continue	Continue Clear
Qwitch	Equal only	Equal only	Equal only	+ 1	+1
Arrows	Left/ Right /Up Down		Alternate color/direction	Continue	Continue

Table A4 continued

Stare Card					
Number Hunt 1-5	Review Add line above 5	Continue Read color Number	Continue	Continue	Continue
Number Hunt 1-9	Read + 1	Read +1	Add Slash 6	Continue	Read = +
Presidents	1-8 Discuss Pictures	1-10	1-10 backward	1--12	1-14
Make a List	Candy		Sports		Animals

Session #	11	12	13	14	15
Reflex Exercises at home Starfish/Finger / Wear Sound Therapy	Do every session and ask if they did the home exercises.				
Xtreme Memory	Continue adding		Continue		Continue
Tic Tac Toe	President		President		Number/ President
Stroop Animal	Continue adding	Continue	Continue	Continue	Continue
Blink	Number, Color ,Shape & Game	Continue	Continue	Continue	Continue
Spot It	Continue	Continue	Continue	Continue	Continue
Set	Full set Use 2 cards find missing	Continue	Continue	Continue	Continue
Qwitch					
Arrows	R/L colors	Number, color		Number, color	

Table A4 continued

Stare Card			Discuss card		Discuss card
Number Hunt 1-5	Continue Read symbols as number	Read symbols as color	Continue	Read Symbols as animals	Number, Color, animal
Number Hunt 1-9	Continue to add	Continue			Continue
Presidents	Continue	Continue	Continue	Continue	
Make a List	Recall items on Spot it cards			Recall Spot it cards	

Session #	16	17	18	19	20
Reflex Exercises at home Starfish/Finger / Wear Sound Therapy	Do every session and ask if they did the home exercises.				
Xtreme Memory	Continue	Continue	Continue	Continue	
Tic Tac Toe		Continue		Continue	Continue
Stroop Animal	Continue		Continue	Continue	
Blink	Continue	Continue	Continue	Continue	Continue
Spot It	Continue	Continue categories	Continue	Continue categories	Continue
Set	Full game		Continue		Continue
Qwitch	Add -	Continue	Continue =. -		=. -
Arrows	Color, direction	Continue	Number, color, direction	Continue	Number, color, direction

Table A4 continued

Stare Card	Discuss			Discuss	
Number Hunt 1-5	Say number, color, animal	Continue	Continue Read = +	Continue	Continue Read minus one
Number Hunt 1-9	Continue adding symbols		Continue		Continue
Presidents	Continue adding	Continue	Continue	Continue	
Make a List	Movie		Snacks		Animals

Session #	21	22	23	24	25
Reflex Exercises at home Starfish/Finger / Wear Sound Therapy	Do every session and ask if they did the home exercises.				
Xtreme Memory	Continue		Continue		
Tic Tac Toe	Continue	Continue	Continue	Continue	Continue
Stroop Animal	Continue	Continue	Continue		Continue
Blink	Continue	Continue	Continue	Continue	
Spot It	Categorize items		Categorize items	Continue	Continue
Set	Continue	Continue	Continue	Continue	Continue
Qwitch	=, +, -			=.+ -	
Arrows	Number, color, direction	Continue Color, president	Continue Number, color, direction, animal	Continue Color, president	Continue Number, color, direction, animal

Table A4 continued

Stare Card		Discuss Card		Discuss card	
Number Hunt 1-5	Continue Number, color, animal		Number, color, animal		
Number Hunt 1-9	Continue	Continue Number, animal		Number, animal	
Presidents	Continue	Continue	Continue	Continue	Continue
Make a List	Movies		Sports		Animals

Session #	26	27	28	29	30
Reflex Exercises at home Starfish/Finger / Wear Sound Therapy	Do every session and ask if they did the home exercises.				
Xtreme Memory	Continue	Continue	Continue	Continue	Continue
Tic Tac Toe	No marking	Continue	Continue	Continue	Continue
Stroop Animal	Continue	Continue	Continue	Continue	Continue
Blink	Continue	Continue	Continue	Continue	Continue
Spot It	Continue	Continue		Continue	
Set	Continue	Continue	Continue	Continue	Continue
Qwitch		=. +, -		=, +, -	

Table A4 continued

Arrows	Number, color, animal, direction	Number, color, animal, direction	Color, president	Number, color, animal, direction	Color, president
Stare Card	Discuss Card			Discuss card	
Number Hunt 1-5	Number, color, direction, animal		Number, color, direction, animal		Number, color, direction, animal
Number Hunt 1-9	Continue +1. +2	Number, color	Continue +1,+2, + 3	Number, color	
Presidents	Continue Recall pictures	Continue	Continue backwards	Continue	Continue
Make a List	Movies	Animals	Sports	Spot it Categories	

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ABSTRACT

EQUIPPING MINDS:
APPLYING A BIBLICALLY BASED CURRICULUM FOR
IMPROVING WORKING MEMORY

Carol Thompson Brown Ed.D.
The Southern Baptist Theological Seminary, 2016
Supervisor: Dr. Danny R. Bowen

Recent findings in neuroscience confirm the neuroplasticity of the brain. There has been strong interest in applying these discoveries to learners with learning disorders focusing on increasing working memory capacity. The aim of the present study was to explore the effectiveness of cognitive intervention with the *Equipping Minds Cognitive Development Curriculum* (*EMCDC*), based on Feuerstein's theory of structural cognitive modifiability. Feuerstein's theory states that a learner's cognitive functioning can be modified through mediated learning. *EMCDC* is aimed at enhancing processing, working memory, comprehension, and reasoning abilities. Participants were learners with Specific Learning Disorders (SLD) Learners were randomly assigned into one of two groups. The active control group received small group intervention in academic subjects an hour a day five times a week for 7 weeks. The training group received small group intervention in the *Equipping Minds Cognitive Development Curriculum* an hour a day five times a week for 7 weeks. Both groups were tested on measures of working memory, verbal and nonverbal ability, and academic attainment before training and re-tested on the same measures after training. Analysis of the pre-to post-test scores demonstrated significant ($p<0.05$) advantage of the training over the

active control group on the *KBIT*-2 in verbal, nonverbal, and IQ composite, as well as far transfer effects in science. This study's design could be replicated in multiple educational settings with other neurodevelopmental disorders.

Key words: Neuroplasticity, cognitive development, Feuerstein, Equipping Minds, mediated learning, working memory, Specific Learning Disorders

VITA

Carol Thompson Brown

EDUCATION

B.A. Rehabilitation Counseling, Marshall University, 1984
M.A.C.S.S. Church Social Services, Southwestern Baptist Theological Seminary, 1987

PUBLICATIONS

Brown, Carol T. "Equipping Minds for Christian Education: Learning from Neuroscience for Christian Educators." *Christian Education Journal* 13, no. 1 (2016): 147–68.
Brown, Carol T. *Equipping Minds Workbook: Cognitive Development Curriculum*. Danville, KY: Equipping Minds, 2015.

MINISTERIAL

Missionary to Lyon, France, Mission to the World, 2002–2004
Crisis Pregnancy Director and Therapist, Missouri Baptist Children's Home, St. Louis, Missouri, 1988–1989
Assistant Director and Therapist, Connie Maxwell Baptist Children's Home, Florence, South Carolina, 1987–1988

ACADEMIC

Head of School, Newnan Classical School, Newnan, Georgia, 2000–2001
Principal, American School of Lyon, Lyon, France, 2002–2004
Head of School, Ad Fontes Academy, Centreville, Virginia, 2004–2009
Executive Director, Equipping Minds, Frankfort, Kentucky, 2009–
Special Needs Consultant, Home School Legal Defense Association, Purcellville, Virginia, 2014–

ORGANIZATIONS

Society for Professors in Christian Education