

# JOURNAL OF ALTERNATIVE MEDICINE RESEARCH

## Special Issue

### Equipping Minds Cognitive Development

## Edited by

**Carol T Brown and Joav Merrick**

**Volume 10, Issue 2, 2018**

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# Journal of Alternative Medicine Research

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*Journal of Alternative Medicine Research*  
is published quarterly by

**Nova Science Publishers, Inc.**  
400 Oser Avenue, Suite 1600  
Hauppauge, New York 11788-3619, U.S.A.  
E-mail: [nova.main@novapublishers.com](mailto:nova.main@novapublishers.com)  
Web: [www.novapublishers.com](http://www.novapublishers.com)

ISSN: 1939-5868

Subscription Rate per Volume

**Paper:** \$325.00    **Electronic:** \$325.00    **Combined Paper and Electronic:** \$487.00

Personal Subscription Rate per Volume

\$50.00

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*Journal of Alternative Medicine Research*  
is abstracted and indexed in

CINAHL, Index Copernicus, Elsevier

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Additional color graphics might be available in the e-version of this journal.

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## **EDITORIAL**



## Equipping Minds Cognitive Development

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### Introduction

Recent findings in neuroscience confirm the neuroplasticity of the brain for learners of all ages and abilities (1-4). There has been strong interest in applying these discoveries to learners with learning disorders focusing on increasing working memory capacity. Numerous research studies have examined the relationship between working memory, cognitive skills, and academic abilities. However, while some studies and scientific articles have demonstrated that working memory can be increased through direct intervention in either the clinical or classroom setting, other studies have failed to show far transfer effects. These conflicting results are a key concern as they suggest that generalization effects are elusive and inconclusive.

Furthermore, 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. An alternative approach absent in the current literature on working memory training is the use of a human mediator. 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 (5).

In this special issue, we present studies, which demonstrated that working memory 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 specific learning disorder. This finding adds to the importance of an emphasis on deficient cognitive functions rather than deficient working memory alone.

To our knowledge, no previous study has demonstrated significant changes in verbal abilities,

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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 psychologists in a discussion on the cognitive modifiability of individuals with neurodevelopmental disorders. It 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.

Seemingly, the naturalistic view of humanity and human development has been widely accepted. Many religious educators have come to accept the theories of human development embraced by secular educational systems 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.

An additional benefit of *EMCDC* is that it can be implemented in a variety of settings from the school, clinic, hospital, and home. Therapists and educators can implement it in a small group as demonstrated in the research study or one on one in person or online. The positive effect seen in learners online allows professionals to reach families around the world who could not otherwise be reached.

The implications for educators and psychologists are substantial since intelligence can be developed when a mediator teaches and trains 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. Recognizing that intelligence can be improved, educators can adapt their teaching for students who have traditionally been viewed as have limited cognitive modifiability and seen as difficult to teach. The current treatments

which have been limited to remediation of content, learning strategies, accommodations, and medication can include training in a cognitive development curriculum.

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## **ORIGINAL ARTICLES**



# Naturalistic or biblical worldview of human development

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## Abstract

A naturalistic view of human development has been prevalent for over 300 years and has gone unchallenged. Upon speaking to educators and psychologists, Piaget's name and theories are renowned and accepted while the names of John Amos Comenius, Shmuel Feuerstein, and Reuven Feuerstein are virtually unknown. However, both Shmuel Feuerstein, and John Amos Comenius challenge the naturalistic view and replace it with a biblical view of human development. Seemingly, the naturalistic view of humanity and human development has been widely accepted. Educators have come to accept the theories of human development embraced by an 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.

**Keywords:** Human development, theist worldview, cognitive development, Feuerstein, equipping minds, Comenius, mediated learning

## Introduction

This article will contrast the naturalistic foundation of human development by cognitive psychologists with a biblical foundation for humanity, knowledge, human development, and mediation.

Many educators have been looking at learners with neurodevelopmental disorders through Piaget's (1896-1980) eyes rather than God's. Seemingly, the naturalistic view of humanity and human development has been widely accepted. Many religious educators have come to accept the theories of human development embraced by secular educational systems 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

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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 (1856-1939) reversed Genesis 1:27 from “God created man in his own image,” into “Man created God in his image” (1). 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” (2).

### *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 (3). His naturalistic views, which have significantly impacted educators’ understanding of human development, have been virtually unchallenged (4). Piaget’s theory of intellectual development has four distinct and progressive stages of development and can also be understood as peoples’ intellectual ability regardless of their age (4). Educators have come to accept the theories of human development embraced by their educational system that discount spirituality and have a naturalist worldview. These developmental theories inform our curricula, determine who may or may not attend schools, define what is normal, and identify one’s cognitive potential based on an intelligence quotient

(IQ), a static assessment (5). 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 (6). 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 (7).

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 private 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 (8).

### *Biblical worldview of human development*

In the 1600s, the father of modern education and reformed theologian, John Amos Comenius (1592-1670) 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” (9). While Piaget had great admiration for Comenius’ work, he dismissed and misunderstood Comenius’ theistic 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 (9).

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” (10). 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....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 likewise” (10). 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. 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” (10).

### *Contrasting naturalistic and theistic worldviews*

A human’s intellectual development, or capacity for rational thought, is present because we are created in the image of God (10). This theological foundation is crucial as we look at how these areas are related. A theistic worldview of humanity asserts that the chief aim of man and all of creation is to glorify God (11). 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 (11). Further areas of examination are the integration of the theistic view of knowledge, human development, and mediation.

### *Creation of humanity*

A creational view of human development includes genetic and physiological, cognitive, emotional, volition, and relational development (12). 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 said, “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” (13). Furthermore, Peter Gentry and Stephen Wellum stated, “The covenant relationship between God and Man is not restricted to an elite sector within human society” (14).

A correct understanding of the *imago Dei* is the basis for 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” (14). This rejection led to the fall of man.

### *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” (13). 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 (12). 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 (12). 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).

Man can be renewed in knowledge and in the image of his Creator, which involves the mind and heart. The image of God includes the whole person, in structure and function (15). 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 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 you 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). (13) 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 neurodevelopmental learning disorders (NLD) as there will be no disabilities in our glorified bodies.

### *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 (1509-1564), “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” (16). 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” (17).

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” (18). It is 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” (19).

Reuven Feuerstein (1921-2014), 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 (19). According to Louis Falik and Refael Feuerstein, regarding the last work by Reuven Feuerstein, *“Changing minds and brains,”* 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” (20).

He studied the Bible throughout his life 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” (19).

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 (19). Shmuel Feuerstein stated, “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” (19).

Comenius and Feuerstein also agreed 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” (19).

## Discussion

The current research study (24) with *EMCDC* 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. Theologians, educators and psychologists 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 (19).

The *EMCDC* (22) 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. Educators, theologians, and psychologists can use *EMCDC* in their schools, churches, and private practice which will impact curricula, admission policies, and ministries in religious schools and churches. The findings from the current research support viewing individuals with a NLD from a biblical worldview whose cognitive abilities can be increased.

## Conclusion

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" (10).

## Ethical compliance

The authors have stated all possible conflicts of interest within this work. The authors have stated all sources of funding for this work. If this work involved human participants, informed consent was received from each individual. If this work involved human participants, it was conducted in accordance with the 1964 Declaration of Helsinki. If this work involved experiments with animals, it was conducted in accordance with the related institutions' research ethics guidelines.

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*Submitted:* February 05, 2017. *Revised:* March 10, 2017.  
*Accepted:* March 19, 2017.



# Computer training or human mediator

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## Abstract

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. An alternative approach absent in the current literature on working memory training 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 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. 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.

**Keywords:** Computer training, cognitive development, Feuerstein, Equipping Minds, mediated learning, working memory, Specific Learning Disorders

## Introduction

In recent years the majority of research studies in peer reviewed journals have utilized computer software programs to enhance cognitive skills. An alternative approach absent in the current literature on cognitive development 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. Hulme and Melby-Lervag (1) evaluated the claims of computer-based cognitive skill programs in a systematic meta-analysis review of the existing studies and they concluded:

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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 (1).

### *Proposed origin and purpose of structural cognitive modifiability*

However, the Feuerstein Institute has conducted research with "Feuerstein Instrumental Enrichment" (FIE) that confirms cognitive abilities can be modified demonstrating far transfer effects and generalized to academics for many years (2). The first program to increase intellectual performance for those with neurodevelopmental learning disorders was developed more than fifty years ago by Reuven Feuerstein (1921-2014), a clinical and cognitive psychologist who studied under Jean Piaget and Andre Ray in Geneva (3). 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 (4). Educators, psychologists, and school counselors embraced Piaget's view (5). Feuerstein, on the other hand, believed that intelligence was changeable and modifiable regardless of age, neurodevelopmental conditions, genetics, and developmental disabilities (3). 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 (3). 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" (6).

Feuerstein's theory is known as structural cognitive modifiability (SCM). His theory of human development has three basic ideas:

- Three forces shape human beings: environment, human biology, and mediation.
- 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.
- 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 (7).

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 (8)!"

### *Mediated learning*

The theory of Mediated Learning Experience (MLE) initially grew as part of Feuerstein's theory of Structural Cognitive Modifiability (SCM) (8). Mediation is an interaction in which a mediator who possesses knowledge intends to convey a particular 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 (9). 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 (3). 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” (4). Feuerstein, however, sees the human mediator as crucial for a learner’s development (3).

Educators who embraced Piaget’s direct approach to learning believed that mediation is unnecessary and interferes with a learner’s independence and sense of freedom (3). These educators believe many learners with neurodevelopmental learning disorders (NLD) are unmodifiable (10). However, educators who implement mediation into their teaching realize that students with NLD can learn and are modifiable (9). 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 (11-13).

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 (11-13).

### *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 attention deficit disorder (ADHD) (11-13). 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 (14). Since the initial study, numerous research studies have been completed showing improvements in working memory (15). *Cogmed* recommends training for 30–45 minutes a day for five weeks, according to Melby-Lervag and Hulme (1).

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 (17). 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 (18).

### *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 (11).

### *Bright start*

Research on the impact of cognitive development programs of children with developmental disabilities, such as Down syndrome and other genetic syndromes, intellectual disabilities, and cerebral palsy is limited (11). 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 (19). 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 (20-21).

### *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 placed a significant role on the adult mediator to enable children to reach higher levels of cognitive abilities (22). 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 thoughtful, more reflective, more considerate, more reasonable individuals” (23).

### *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 (3). 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” (3)?

“Belief in modifiability” is an essential element of Feuerstein’s theory of structural cognitive modifiability (3). 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 (24). In *Changing minds and brains*, Feuerstein states, “I have come to believe that spiritual thinking and behavior produces changes in the gray matter of the brain (9).” Christian educators agree that our faith consists of belief and trust, and also impacts who we are (25).

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 (8). 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” (26).

Feuerstein studied at the University of Geneva, completing degrees in general and clinical psychology (in 1952) and obtained a license in psychology (in 1954). In 1970 he earned his PhD 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 in 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.

### *Instrumental enrichment*

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 learning capacity (7).

### *Research studies on cognitive enhancement*

The Feuerstein Institute has conducted research that confirms cognitive abilities can be modified (2). Instrumental Enrichment (FIE) and MLE have been found to enhance cognitive abilities of learners with neurodevelopmental learning disorders (11). Many of these learners also have cultural deprivation and differences. These studies have encompassed many types of student populations using FIE (7). 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 (27). 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 (28).

### *Autism*

Research in the field of autism continues to develop. The research staff at 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 (29). Gross and Stevens demonstrated improvements in visual attention and tracking, following directions, understanding cause and effect, turn taking, making choices, and predication and persistence (30).

### *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 (31). 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 (32).

### *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 WISC-R subtests of similarities, picture completion, and picture arrangement, as well as on Raven's Colored Matrices (11).

In 2014, Krisztina Bohács studied learners from two to fourteen years of age with mild to moderate intellectual developmental disorders, including genetic syndromes, cerebral palsy, 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" (33).

#### *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)* (18) from 2011-2015 with a learner with a NLD, namely Down syndrome (34-35). In September 2011, Marie's parents contacted Brown to discuss using *EMCDC* to strengthen Marie's cognitive abilities; 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 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 measurable 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 (36). Since Marie has an intellectual disability and Down syndrome, many educators believe these disorders limit her ability for significant academic gains. Educator, 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. She stated that the gains in processing and working memory were greater than she had ever seen (41). 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 Mervis due to other research commitments within the department (42). 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 1-4 illustrate recreations of the MAP test results which demonstrate significant gains in academic abilities. 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. See figures below.

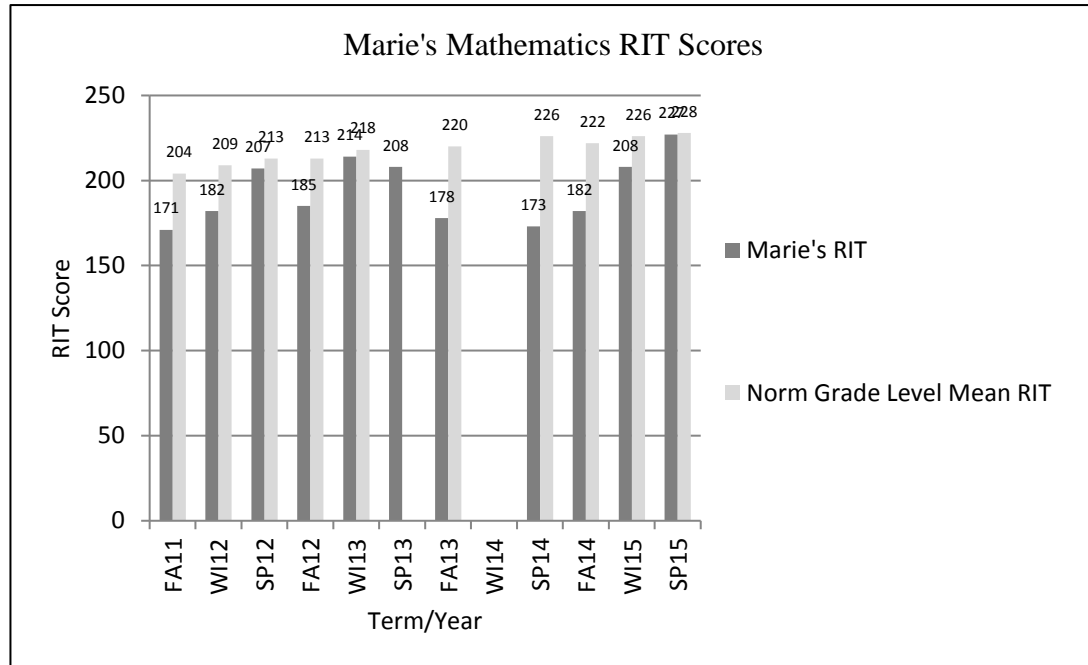


Figure 1. Marie's mathematics RIT scores.

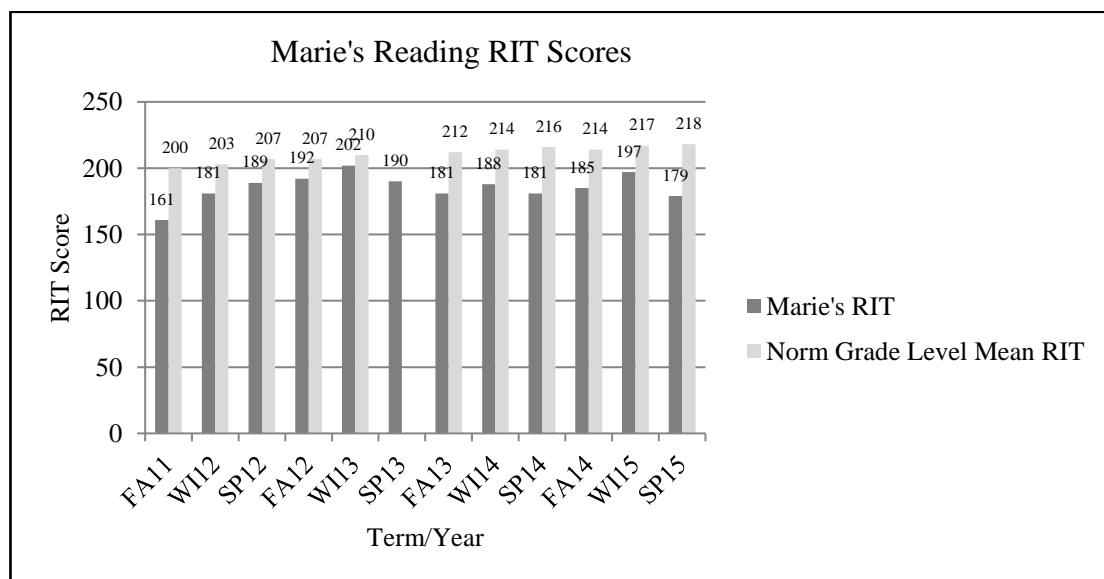


Figure 2. Marie's reading RIT scores.

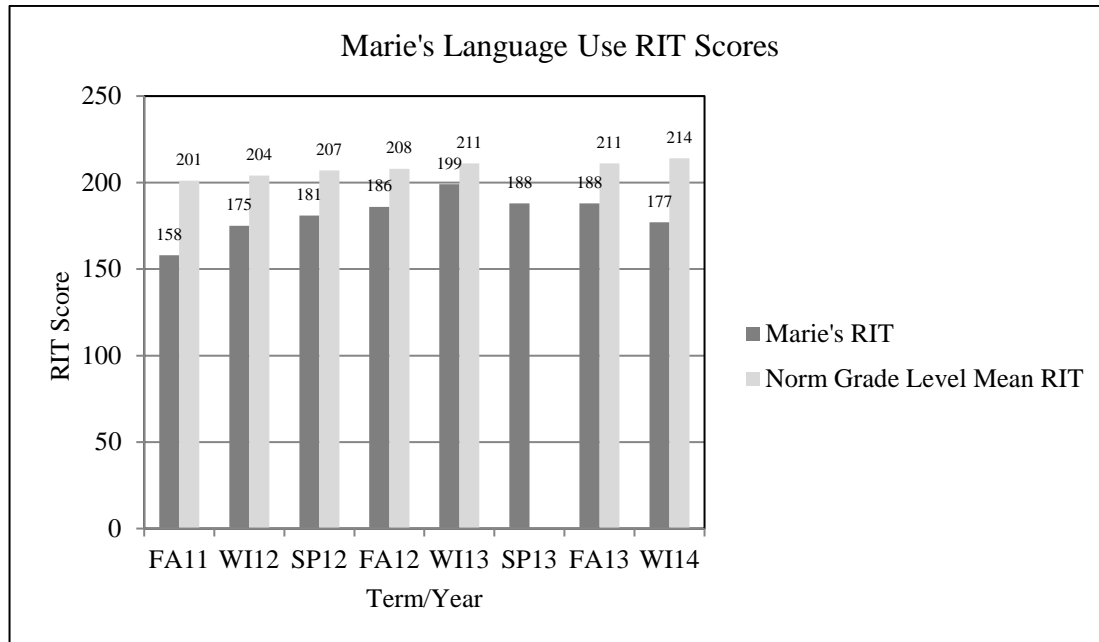


Figure 3. Marie's language RIT scores

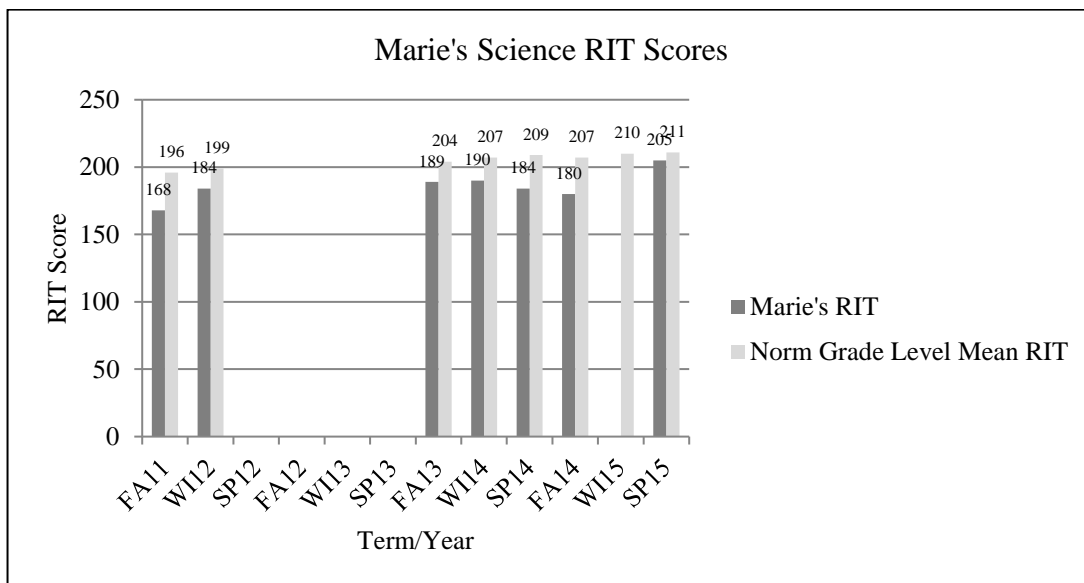


Figure 4. Marie's science RIT scores.

Marie would continue the cognitive developmental exercises and continue to progress academically for the next four years. Re-creations of her Kentucky Performance Rating for Educational (KPREP) scores are illustrated on Figures 5-7 showing gains in math, reading, 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. 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 8

illustrates a re-creation of the SCP for sixth and seventh grade. In 2015, as a seventh grader, she scored in the 39<sup>th</sup> percentile in mathematics, 36<sup>th</sup> percentile in science, and the 7<sup>th</sup> percentile in reading on the Stanford Ten National Assessment Ranking. Figure 9 illustrates a re-creation of the Stanford National Ranking.

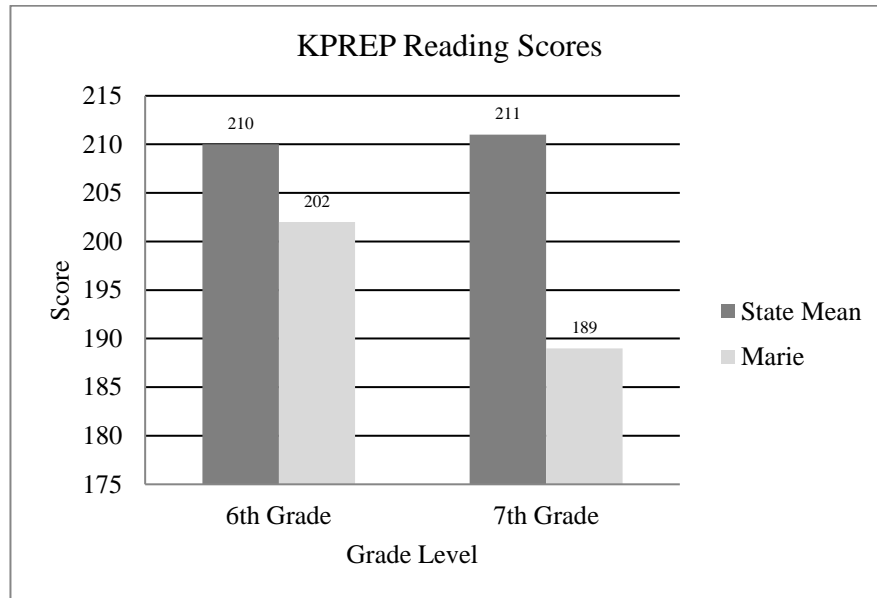


Figure 5. KPREP reading scores.

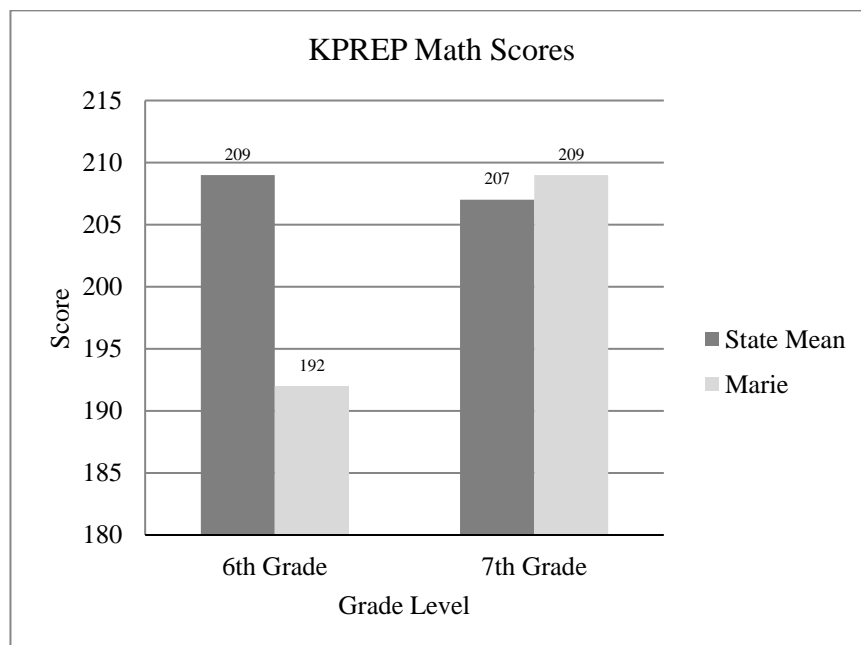


Figure 6. KPREP math scores.

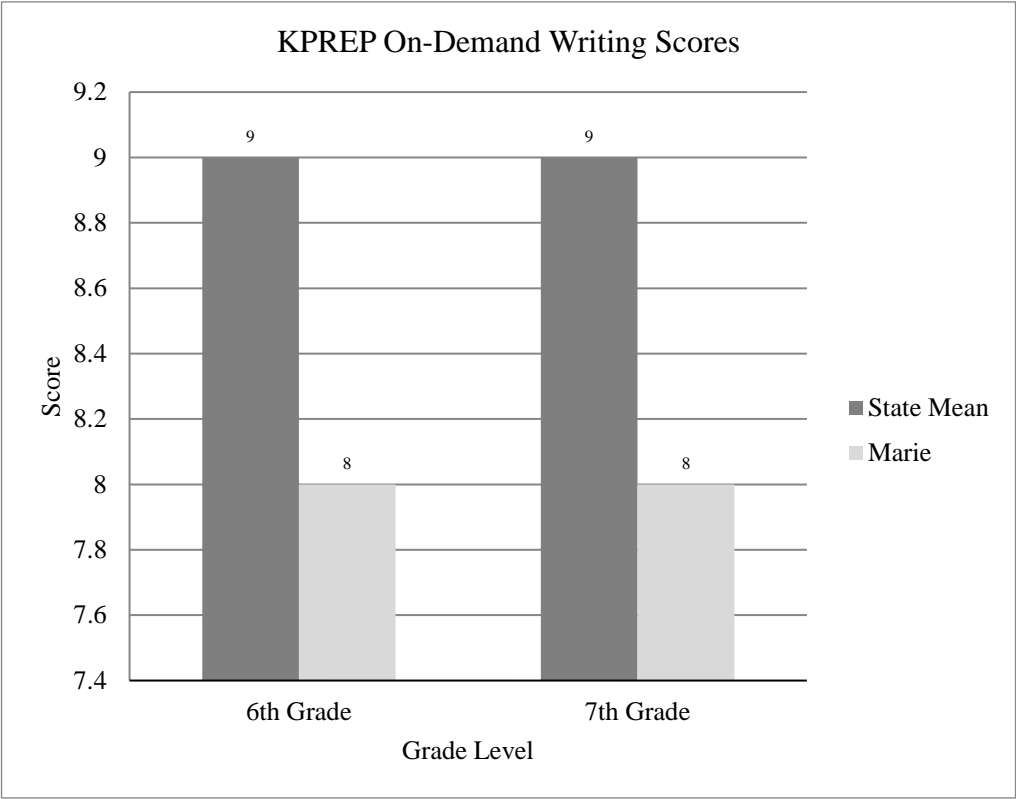


Figure 7. KPREP on-demand writing scores.

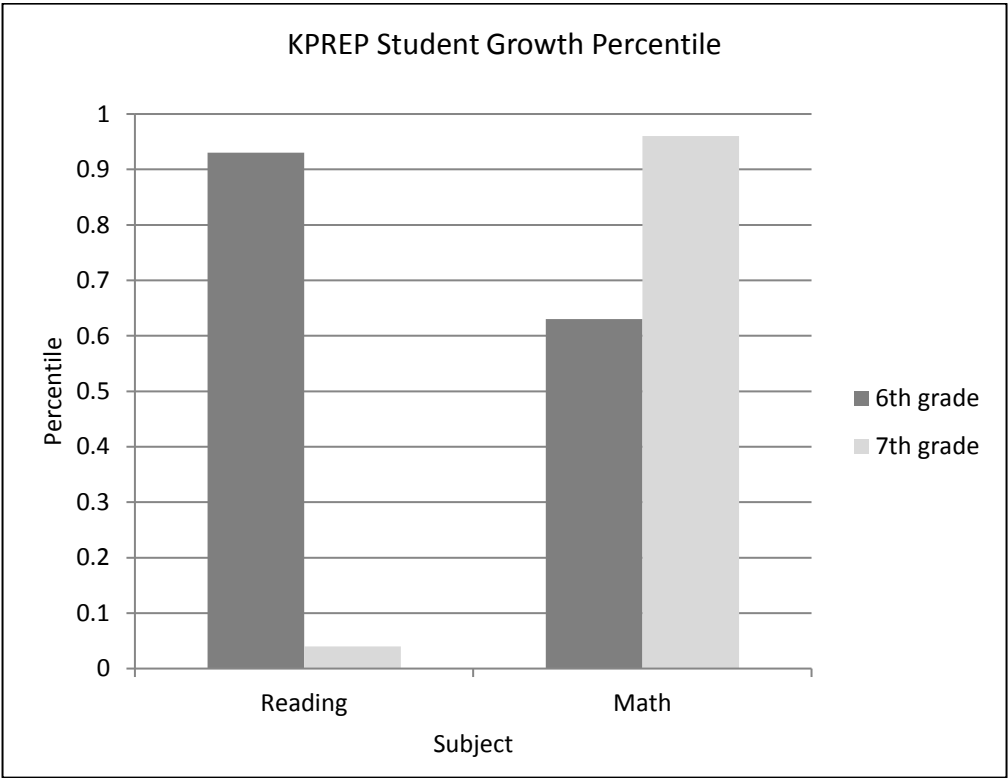


Figure 8. KPREP student growth percentile.

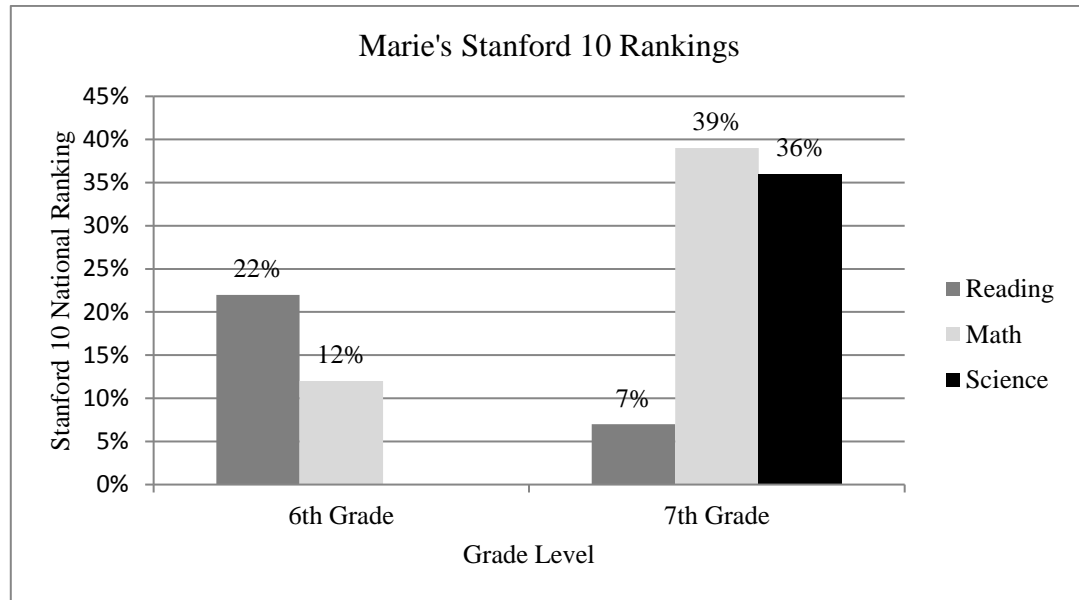


Figure 9. Marie's Stanford 10 rankings.

## Discussion

The implications for public, private, and religious school practitioners, higher education practitioners, 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. 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 church. Yet, less than 10 percent of the churches in the U.S. have an intentional disability ministry or outreach (37).
2. This study may benefit private and religious 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 private and religious school will no longer need to refer parents to public schools but will be able to include more students with NLD in the private and religious school setting.
3. This study may benefit 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.
4. This study may benefit Teacher Education Programs for the course Teaching Exceptional Learners.

5. This study may benefit 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.
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 (38). The Home School Legal Defense Association has over 14,000 families who subscribe to the struggling learners newsletter (39).
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. Missionaries will also be equipped to 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 (40). Adopted and foster children need guidance in learning to relate to others. Parents are encouraged to intentionally interact with their child (40).

## 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 (11).

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 (11).

## Ethical compliance

The authors have stated all possible conflicts of interest within this work. The authors have stated all sources of funding for this work. If this work involved human participants, informed consent was received from each individual. If this work involved human participants, it was conducted in accordance with the 1964 Declaration of Helsinki. If this work involved experiments with animals, it was conducted in accordance with the related institutions' research ethics guidelines.

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*Submitted:* February 20, 2017. *Revised:* March 30, 2017.  
*Accepted:* April 06, 2017.



## Correlation between working memory, intelligence, and cognitive functions

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### Abstract

While man has been fascinated with memory, intelligence, 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 disorders. Researchers have found reliable correlations between working memory span and several other measures of cognitive functions, intelligence, and performance in school. Working memory deficits impact all learners with a neurodevelopmental learning disorder. Given the correlation between working memory and academic success, researchers have studied the effects of training working memory. However, the results suggest the interventions are not generalizing to academics in students with a neurodevelopmental learning disorder. Rather than focusing on the deficits in working memory, Reuven Feuerstein takes a broader perspective and examines the cognitive functions 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. 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.

**Keywords:** Working memory, intelligence, Feuerstein, cognitive functions, neurodevelopmental learning disorders

### Introduction

Developing one's mental capacities has been a valuable skill for thousands of years. According to Frances Yates (1899-1981), "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" (1). 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

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memory in *De oratore* (1). 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 (2).

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 that connected memories to emotions experienced during the event, according to Herrmann and Chaffin (2).

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" (3). 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" (4)?

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" (4). 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 (4). In teaching them something new, knowledge must begin with illustrations from everyday life. First, exercise the learner's senses, then form memories through images that lead to comprehension and discernment of the information (4).

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 (5). 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 (5).

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)" (6-7).

### *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* (8). 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’ (8).

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 (9).

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 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 (10-11). 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 (10-11). Their theory emphasized the importance of cognitive functions (12). Figure 1 illustrates their flow of information (10-11).

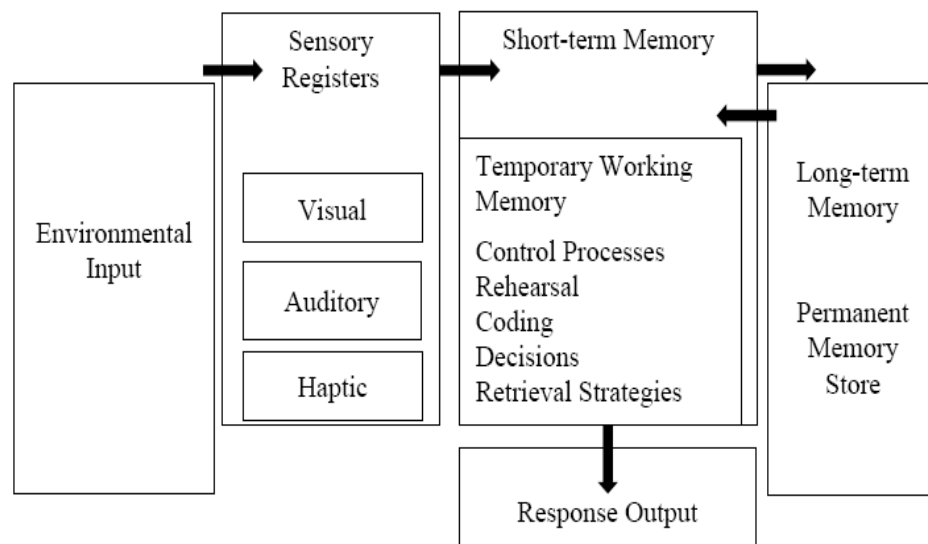


Figure 1. The flow of information through the memory system, Atkinson and Shiffrin.

While the multi-store model introduced the controlled process of transferring 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 (12).” 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 (13).

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 (14). 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 (15).

### *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. Psychologist 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" (11). 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 (16). Baddeley and Hitch stated from the argument that working memory was a flexible and complex system with subcomponents (17). 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 (17). 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 (16) and can be seen in Figure 2 (16).

### *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" (11).

### *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 (18). Successful vocabulary acquisition has been claimed to be the single most important determinant of a child's eventual intellectual and educational attainments (19).

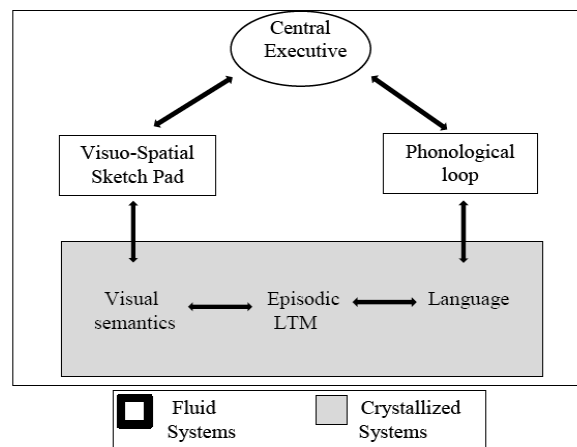


Figure 2. A modification of the original model to take account of the evidence of links between working memory and long-term memory.

### *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 (20).

### *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 (21).

### *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 BCE (22). These proficiency tests were given every three years. As the Chan dynasty began, candidates for public office were given a formal ability test (22).

### *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 (22). Next, French physician, Jean-Marc Gaspard Itard, was recognized as one of the founding fathers of special education (23). Itard is known for his work with the child referred to as “the Wild Boy of Aveyron” (24). He was the first physician to declare that an enriched environment could compensate for developmental delays caused by heredity or previous deprivation (25). 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” (26).

Itard’s influence was extended through the work of his pupil, Eduard Séguin (22). 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 (22).

### *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 (27). 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 (27). Galton’s theory also stated that individuals take information through their senses, and intelligence would increase if sensory abilities could be increased (22).

### *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 (28). In a study by PC 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*" (29). 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 (20). Spearman also introduced the *specific* factor which correlated to an individual's unique or specialized abilities (5).

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 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 (20). 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" (30).

Binet's assessment spread to the United States with HH 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 (22). In 1922, Terman stated, "There is nothing about an individual as important as his IQ, except possibly morals" (31). The Stanford-Binet had become the standard for IQ testing in the United States.

**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)	

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 (5). Noticing the inadequacies in the assessment, Wechsler believed that the deficiencies found in soldiers were due to a lack of education rather than a lack of intelligence (32). 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” (5). 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 (5). The composite scoring and origin of the subtests are seen in Table 1 (33). 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 (33).

### *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 (20). 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 (34).

In recent years “working memory” has been a key factor in determining fluid intelligence (35). Numerous studies have shown that an individual’s working memory capacity predicts performance in both language and mathematical skills on national curriculum tests (36-38). Furthermore, low working memory capacities in children with or without learning disabilities result in academic difficulties (39-42). Working memory is 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 (42-44).

### *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 (33).

### *Alloway working memory assessment, 2<sup>nd</sup> 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 (45-46). 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 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 (45). Table 2 illustrates the eight tests which comprise the *AWMA-2*.

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

<i>VERBAL STM</i> Digit Recall Letter Recall	<i>VERBAL WM</i> Backward Digit Recall Processing Letter Recall
<i>VISUOSPATIAL STM</i> Dot Matrix Block Recall	<i>VISUOSPATIAL WM</i> Mr X 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 (47). 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” (48). 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 (46). 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 (49-50).

### *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 (51). 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 (52).



### *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 (48). An IQ score of 65–75 ( $70 \pm 5$ ) is the criterion for the diagnosis and further assessments by a clinician are needed to determine the severity level (48).

### *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 (46). SLI children typically have below-average performance in tests of verbal short-term memory and working memory (53). 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 (46).

### *Motor disorders*

“Motor disorders” replaces the previous categories of developmental coordination disorder (DCD) and tic disorders (51). 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 (54). However, once they also 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 (55). 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 (56).

### *Specific learning disorder (SLD)*

Specific learning disorder (SLD) 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 frustration when they encounter new vocabulary words or challenging texts (46).

Dyscalculia, or mathematics disorder, is where students struggle to learn or understand mathematics. An estimated 5–8 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 (57), and once they reach adolescence, verbal working memory is no longer significantly linked to mathematical skills (58). 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 (59). 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 (60).

### *Cognitive functions*

The review of NLDs show a deficit in working memory abilities for learners diagnosed with ADHD, specific learning disorders, motor disorders, communication disorders, autism spectrum disorders, and intellectual disabilities. While this correlation has led many psychologists to focus on working memory training, Reuven Feuerstein takes a broader view and 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 (61). 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 (61). 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 (62) can differentiate between errors due to a lack of knowledge or from a deficient cognitive function (61). 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 (63).

### *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 (61).

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 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 (61).

*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 plan, state the steps, and provide the reasons (61).

*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 (61).

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 (64).

### *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 (64).

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 (64).
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 (64).

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" (64)?
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 (64).

### *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 (12). 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" (12).

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 (12). However, the assessment was not without challenges. There was insufficient 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 (12).

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" (12).

## Conclusion

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 disorders. Over the last twenty years, research on working memory found reliable correlations between working memory span and several other measures of cognitive functions, intelligence, and performance in school (65). Recent studies on individual differences in mathematical abilities show that aspects of working memory contribute to early arithmetic performance (66). Further studies examine the relationship between working memory, reading, and comprehension (67-68). 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 (69-70).

Working memory deficits impact all learners with a NLD (47). 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" (48). This was the 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 (71). 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 (61). 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 affect thinking (61). 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 (62) can differentiate between errors due to a lack of knowledge or from a deficient cognitive function (61). 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 (63).

Cognitive developmental exercises could be incorporated into the teaching curriculum for every learner in the school, church, and home. Strengthening cognitive abilities with the FIE and *EMCDC* has far transfer effects to academics.

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 (64). *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 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.

## Ethical compliance

The authors have stated all possible conflicts of interest within this work. The authors have stated all sources of funding for this work. If this work involved human participants, informed consent was received from each individual. If this work involved human participants, it was conducted in accordance with the 1964 Declaration of Helsinki. If this work involved experiments with animals, it was conducted in accordance with the related institutions' research ethics guidelines.

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*Submitted:* February 15, 2017. *Revised:* March 15, 2017.  
*Accepted:* March 30, 2017.



# Cognitive development curriculum increases verbal, nonverbal, and academic abilities

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## Abstract

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 (SCM). 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 seven weeks. The training group received small group intervention in the *EMCDC* an hour a day five times a week for seven weeks. Both groups were tested on measures of working memory, verbal and nonverbal ability, and academic attainment before the training and re-tested on the same measures after training. Analysis of the pre-to post-test scores demonstrated a significant ( $p < 0.05$ ) advantage for the training group 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.

**Keywords:** Neuroplasticity, cognitive development, Feuerstein, Equipping Minds, mediated learning, working memory, Specific Learning Disorders

## Introduction

"So unlimited is the capacity of the mind that in the process of perception it resembles an abyss," wrote the father of modern education, John Amos Comenius in 1657 (1). Three hundred years later cognitive psychologist, Reuven Feuerstein (1921-

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2014) proclaimed, “Intelligence is modifiable!” (2). Nonetheless, a *fixist* view of intelligence was prevalent for those with neurodevelopmental learning disorders, injury, and disease until the recent discovery of neuroplasticity by Eric Kandel which showed that learning ignites genes which change neural structure (3). 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 (4). This discovery has led to a growing interest in training working memory capacity.

Over the last twenty years there has been an increased interest in the relationship between working memory, cognitive skills, and academic abilities as evidenced in numerous research studies (5, 6). A review of neurodevelopmental learning disorders shows a deficit in working memory abilities for learners diagnosed with ADHD (attention deficit hyperactive disorder), specified learning disorders, motors disorders, communication disorders, autism spectrum disorders, and intellectual disabilities as indicated on psychological assessments (7). In response to this link between working memory and a multitude of deficits, there is immense interest and controversy in working memory training. Numerous research studies and scientific articles have demonstrated that working memory can be increased through direct intervention in either the clinical or classroom setting (8-10). Jaeggi and colleagues (8) stated: “Evidence is accumulating through some research that some working memory 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, working memory 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” (8). However, other studies have failed to show far transfer, suggesting that generalization effects are

elusive, inconclusive and controversial. 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 (8).

It should be noted that 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. In a systematic meta-analysis of the existing studies on the benefits of computer-based working memory training, Hulme and Melby-Lervag (11) concluded that these working memory 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. Consequently, working memory training programs will not provide general improvements in adults’ or children’s cognitive skills or scholastic attainments.

However, in a recent study by Alloway, Bibile, and Lau (12) using the computer program *Jungle memory*, three groups of learners with learning difficulties were tested on measures of working memory, verbal and nonverbal ability, and academic attainment before training and then again after training. The groups were re-tested 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 over the low-frequency active control group.

An alternative approach absent in the current literature and research on working memory and cognitive skill training are programs that do not utilize a computer-based program but 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. For over forty years, the Feuerstein Institute has conducted research with “Feuerstein Instrumental Enrichment” (FIE) that confirms cognitive abilities

can be modified demonstrating far transfer effects and generalized to academics (13-15). FIE is based on the theory of structural cognitive modifiability (SCM) and the application of the mediated learning experience (MLE) (13). 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 child to transcend, that is, to relate the meaning to some other thought or experience (16).

Another difference between Feuerstein and the current working memory training programs is that Feuerstein examines the cognitive functions underlying intelligence and what is going on in the learner's mind rather than working memory alone. Feuerstein defines cognitive functions as "thinking abilities" that can be taught, learned, and developed (13). 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. By having a working knowledge of the cognitive functions, teachers can differentiate between errors due to a lack of knowledge or from a deficient cognitive function (13). 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. Feuerstein has sought to identify and correct these deficits to enable students to reach their full cognitive potential. By using mediation, these deficient functions can be corrected, formed, and modified in significant ways (17).

The *Equipping Minds Cognitive Development Curriculum* (EMCDC) (18) is based on the theory of Structural Cognitive Modifiability" (SCM), "Mediated Learning Experience" (MLE), and developing cognitive functions and abilities. An

individual four year case study was done with the *Equipping Minds Cognitive Development Curriculum* (EMCDC) from 2011-2015 on a learner with a neurodevelopmental disorder (Down syndrome) (19). The author worked with the learner an hour of every school day. At the end of nine weeks, academic testing demonstrated significant gains in reading, math, science, and language arts. Until this time, the learner had made minimal progress and her academic test scores had remained static. The change in these scores had been achieved through one-on-one cognitive developmental exercises for enhancing processing, working memory, comprehension, and reasoning; this was divorced from academic content. Previously, the learner 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.

Over the next four years the academic test results demonstrated significant gains in academic abilities (19). These results were foundational to the current study with EMCDC. The current research seeks to engage educators and psychologists 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 academic and cognitive formation. The purpose of this study was to examine the effect of the *Equipping Minds Cognitive Development Curriculum* (EMCDC) (20) on working memory in students diagnosed with specific learning disorders (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. Specifically, the study sought to answer the following research questions:

- What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum*?

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

## Methods

The research design was a true quantitative experimental study of the effects on working memory when applying the *Equipping Minds Cognitive Development Curriculum (EMCDC)* among learners diagnosed with specific learning disorder (SLD). Compilation began with the recruitment and identification of learners with SLD and qualified mediators. Then, 32 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* and the active control group received academic training. After the intervention, post-tests were administered. A statistician conducted a statistical analysis of the data collected. This compilation occurred in five phases.

In phase one, a private school who serves learners with SLD initiated contact with *Equipping Minds* which allowed access to 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. 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 who were trained in *EMCDC* for the study.

In phase two, the school administration randomly allocated all participants to either the active control or the training group upon receipt and examination of all the participation forms. 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. Qualified professionals administered a pretest with the *Kaufman Brief Intelligence Test*, 2<sup>nd</sup> ed. (*KBIT-2*), a brief intelligence test which measures verbal and nonverbal intelligence for individuals from 4 to 90 years of age. 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 (21). At the time of pre-test, participant allocation into the groups had not been disclosed to anyone testing the participants. The testing took place at the school and took approximately 30 minutes for each participant to complete.

Qualified professionals administered a pretest with a beta version of the *Automated Working Memory Assessment* 2<sup>nd</sup> ed. (*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 (22). 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. 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 (22).

As noted, all of the participants had completed the *TerraNova* academic testing in 2015. The *TerraNova* is a standardized academic assessment for 2<sup>nd</sup>-12<sup>th</sup> 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 (23). 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. This also strengthened the results of the academic assessments as all the students attended the same school for two years. The only difference between the students was either seven weeks of intervention in the training group with cognitive developmental training or seven weeks of intervention in the active control group with academic training.

In phase three, the participants in the training group received cognitive developmental training for 60 minutes, 5 days a week for seven weeks in a small group of two participants with a trained mediator using *EMCDC*. This curriculum is based on the theory of Structural Cognitive Modifiability (SCM) and Mediated Learning Experience (MLE). The cognitive developmental exercises set asked 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.

*EMCDC* 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 (24) and the fear paralysis exercises (25) 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 (26) 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. Brown was also available to answer questions from the mediators and observe the participants’ progression. The participants in the active control group received academic training with a teacher for 60 minutes, five days a week for seven weeks in a small group. All participating learners continued to receive standard special educational support services as a result of their learning difficulties.

In phase four, a qualified professional 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* is an untimed test and takes approximately 15 to 30 minutes to administer. Those administering the test noted more thoughtful responses by those in the training group. The *AWMA-2* was administered on a computer by 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.

### *Data analysis*

In phase five, 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*. To examine the gains as a function of cognitive developmental training, a statistician 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. In order to answer questions 1, 2, and 3, a series of paired *t*-tests was used to determine the statistical significance between the pre-test and post-test scores in both the active control and training group. A regression analysis was performed to determine the effect of training using *EMCDC*. 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.

## Results

Research Question 1 asked, “What, if any, are the effects on working memory when applying the *Equipping Minds Cognitive Development*

*Curriculum?*” The results in Table 1 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.

When applying a regression analysis, the results in Table 2 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.

**Table 1. 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 2. 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.

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 asked, “What, if any, are the effects of changes in working memory to academic abilities in learners using the *Equipping Minds*

*Cognitive Development Curriculum?* The results in Table 3 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. When applying the regression analysis, the findings in Table 4 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.

**Table 3. Grade equivalent academic scores for SLD**

Measures	Active Control			Training Group		
	M	t <sub>(15)</sub>	Pre-to-Post (p)	M	t <sub>(15)</sub>	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 4. 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.

Research question 3 asked, “What, if any, is the effect of working memory on non-verbal and verbal abilities?” The findings in Table 5 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.

When applying the regression analysis, the findings in Table 6 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 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.

The findings in Table 7 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.

**Table 5. 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.

**Table 6. 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.



**Table 7. 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 <sup>2</sup>
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
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.

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 7 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.

## Discussion

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. Thirty hours of intervention with *EMCDC* significantly improves science scores

demonstrating far transfer effects in learners with a SLD (see research question 2).

4. *EMCDC* increases cognitive abilities of verbal, nonverbal, and IQ composite despite insignificant measurable changes in working memory (see research question 3).
5. 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).
6. 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).
7. *EMCDC* impacts males more significantly than females in reading and science (see research question 4).
8. Older students are more likely to exhibit significant improvement in test scores on the Verbal Working Memory test (see research question 5).

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 (7). 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. (12) Alloway, Bibile and Lau's research study 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. 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. While this study had an active control group, the low frequency intervention was once a week (12).

In response to the second research question, 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 which received one 30 hours of additional academic training.

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 four-year case study with *EMCDC*, the strongest academic gain was in science after completing 45 hours of intervention (19).

As noted, Alloway, Bibile and Lau's study (19) demonstrated significant gains in spelling as did the current research and 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 *EMCDC* case study with a learner with Down syndrome who did *EMCDC*, mathematics was the least significant gain at 45 hours. After the completion of 60 hours, the mathematics scores made significant academic gains and continued to increase over the next four years, as she tested in the 39<sup>th</sup> percentile on the Stanford 10 in mathematics. (19)

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 (8). In response to the third research question, 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 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 abilities, nonverbal abilities, and IQ composite 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 (27). The results of the current research support a holistic approach with *EMCDC* by training working memory, processing, comprehension, and reasoning abilities to increase verbal abilities, nonverbal abilities, 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) and Mediated Learning Experience (MLE). 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 potential (28). 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.

The fourth research question examined whether a 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 seven males in the training and the active control group and nine 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.

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 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.

## Conclusion

Additionally, this present study demonstrated that it is 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 seven weeks. The current research found that training in working memory, processing, comprehension, and reasoning with a holistic approach 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 gains using *EMCDC*. The results support the theories of MLE and SCM and the research of

Feuerstein (28). *EMCDC*'s use of a human mediator and cognitive developmental exercises, have a greater impact than working memory training by a computer program alone.

Finally, the implications for educators and psychologists are substantial since intelligence can be developed when a mediator teaches and trains a learner with a specific learning disorder. The current treatments which have been limited to remediation of content, learning strategies, accommodations, and medication can include training in a cognitive development curriculum. Educational settings which view cognitive development as a goal in itself and view the teacher as a mediator can use *EMCDC* in their classrooms.

## Ethical compliance

The authors have stated all possible conflicts of interest within this work. The authors have stated all sources of funding for this work. If this work involved human participants, informed consent was received from each individual. If this work involved human participants, it was conducted in accordance with the 1964 Declaration of Helsinki. If this work involved experiments with animals, it was conducted in accordance with the related institutions' research ethics guidelines.

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*Submitted:* February 05, 2017. *Revised:* March 10, 2017.  
*Accepted:* March 19, 2017.



## **CASE REPORT**





# Equipping Minds cognitive development training in learners with neurodevelopmental disorders: Case studies

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## Abstract

The *Equipping Minds Cognitive Development Curriculum (EMCDC)*, a holistic cognitive intervention program, is based on the theory of Structural Cognitive Modifiability (SCM) and Mediated Learning Experience (MLE) of Reuven Feuerstein. *EMCDC* has been applied with learners of all ages with learning and neurodevelopmental disabilities in the United States and internationally. Five case studies of learners with a neurodevelopmental disorder are presented. Brown utilized the following data collection techniques: clinical observations of the learners, examining and analyzing the psychological and educational documents, and interviewing the parents, the learners, and teachers. Cognitive and academic gains were demonstrated in all of the case studies. The results are consistent with the results of Brown's doctoral research with learners with a Specific Learning Disorder (SLD) and the four -year case study with Marie who had Down syndrome. Family members, therapists, and teachers were included in the therapy sessions and instructed how to interact and instruct using mediated learning. This suggests that a comprehensive intervention program which addresses numerous cognitive functions and includes parents and other professionals in the learner's life allows more opportunities for modification.

**Keywords:** Cognitive development, Feuerstein, equipping minds, autism, post traumatic concussion syndrome, mediated learning

## Introduction

"We know how to test it, you know how to train it" was the consensus of the psychiatric medical residents and faculty who experienced the cognitive development exercises of *Equipping Minds Cognitive Development Curriculum (EMCDC)*. While psychiatrists and educators are aware of the discovery of neuroplasticity, the methods to modify the brain seem illusive. The neuropsychological and educational reports the author has read contain numerous

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recommendations for accommodations, medication, academic remediation, and strategies. Though some reports may state that IQ is not static, the majority of reports give no hope for cognitive modifiability if a learner has a neurodevelopmental learning disorder (NLD): ADHD (attention deficit hyperactive disorder), specified learning disorder, motor disorder, communication disorder, autism spectrum disorder, and intellectual disability. The most common therapeutic interventions will be speech therapy, occupational therapy or physical therapy in the schools on a limited basis while parents who want intensive services must find a private provider. Cognitive therapy interventions are rarely mentioned even though the Feuerstein Institute has conducted numerous research studies that confirm cognitive abilities can be modified in learners with a neurodevelopmental disorder (1).

In fact, as the author has spoken to various educational groups, the work of Reuven Feuerstein (1921-2014) is virtually unknown in the United States. Feuerstein, a clinical and cognitive psychologist, believed that intelligence was changeable and modifiable regardless of age, neurodevelopmental conditions, genetics, and developmental disabilities (2). 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 (2). Feuerstein's theory is known as structural cognitive modifiability (SCM). His theory of human development has three basic ideas:

- Three forces shape human beings: environment, human biology, and mediation.
- 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.
- 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 (3).

Feuerstein insisted that human cognitive abilities can be changed even if the neuro-developmental condition is generally considered irrevocable and irreparable (3). The Feuerstein Institute has conducted research that confirms cognitive abilities can be modified (1). Instrumental Enrichment (FIE) and MLE have been found to enhance cognitive abilities of learners with neurodevelopmental learning disorders (4). Many of these learners also have cultural deprivation and differences. These studies have encompassed many types of student populations using FIE (3).

### *Mediated learning*

The theory of mediated learning experience (MLE) initially grew as part of Feuerstein's theory of structural cognitive modifiability (SCM) (5). Mediation is an interaction in which a mediator who possesses knowledge intends to convey a particular 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. Feuerstein sees the human mediator as crucial for a learner's development (5).

### *Cognitive functions*

The review of NLDs show a deficit in working memory abilities for learners diagnosed with ADHD, specific learning disorders, motor disorders, communication disorders, autism spectrum disorders, and intellectual disabilities. While this correlation has led many psychologists to focus on working memory training, Reuven Feuerstein takes a broader view and 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 (61). 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 (3). 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 (6) can differentiate between errors due to a lack of knowledge or from a deficient cognitive function (3). 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 (7).

#### *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 (3).

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 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 is 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 (3).

#### *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 plan, state the steps, and provide the reasons (3).

#### *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 (3).

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 (2).

#### *Equipping Minds Cognitive Development Curriculum*

The *Equipping Minds Cognitive Development Curriculum (EMCDC)* seeks to correct these deficient cognitive functions through cognitive developmental exercises based on the theory of Structural Cognitive Modifiability (SCM), Mediated Learning Experience (MLE), and a biblical worldview of human development (see table 1). In Brown's doctoral research with *EMCDC*, the 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 seven weeks. The training group received small group intervention in the *EMCDC* an hour a day five times a week for seven weeks. All participating learners continued to receive standard special educational support services as a result of their learning difficulties. Both groups were tested on measures of working memory, verbal and nonverbal ability, and academic attainment before the training and re-tested on the same measures after training. Analysis of the pre-to post-test scores demonstrated a significant ( $p < 0.05$ ) advantage for the training group over the active control group on the *KBIT-2* in verbal, nonverbal, and IQ composite, as well as far transfer effects in science. 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* for 30 hours (4).

While computerized cognitive training programs are prolific, *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 (5-7). 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 mediating within the curriculum is specified in the teacher workbook and summarized in table 2. While the model of mediation is the same for all learners, individualization will occur based upon the learner's progression. By using mediation, these cognitive functions can be corrected, formed and modified in significant ways enabling students to reach their full cognitive potential (8).

Furthermore, *EMCDC* 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 (9) and the fear paralysis exercises (10) are done by the participants at home or at school for 15 minutes a day. The sensory-motor development exercises include the use of sound therapy (11) which the participants wear during the *EMCDC* intervention sessions while doing the cognitive developmental exercises. The mediators follow the *EMCDC* full program as the intervention is typically 60 hours over 12-20 weeks (12).

An individual four-year case study was done with the *Equipping Minds Cognitive Development Curriculum (EMCDC)* (12) from 2011-2015 on a learner with a neurodevelopmental disorder (Down

syndrome) (13-14). The author worked with the learner an hour of every school day. At the end of nine weeks, academic testing demonstrated significant gains in reading, math, science, and language arts. Until this time, the learner had made minimal progress and her academic test scores had remained static. The change in these scores had been achieved through one-on-one cognitive developmental exercises for enhancing processing, working memory, comprehension, and reasoning; this was divorced from academic content. Previously, the learner 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. Over the next four years the academic test results demonstrated significant gains in academic abilities (13-14).

Single N-back task (1958) and Dual N-back task (2003) have been used in research as a method to train working memory for many years. Some studies have reported near transfer effects but failed to demonstrate far transfer effects confirming that generalization remains elusive (15, 16).

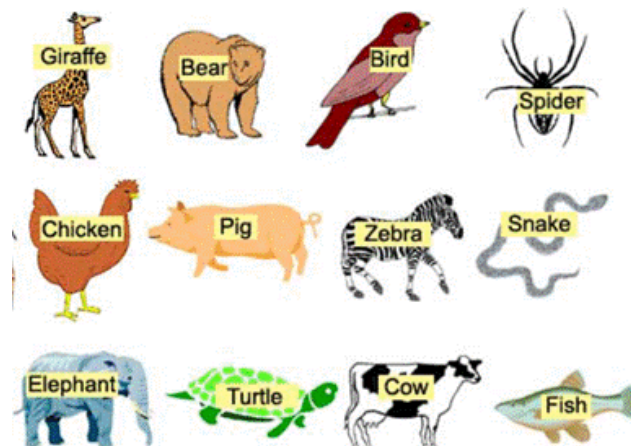
Brown developed an adaptive n-back with six tasks or the "Brown Six N Back" in which learners were asked to associated animals with symbols, letters with sound, symbols and colors, numbers with symbols and colors, recall images and sequence of US presidents, identify colors, and identify directions of left, right, up, and down. To Brown's knowledge, there has not been a Six N-back task which utilizes a human mediator requiring the learner to hear auditory instructions, use their hands to write or place a cube while holding a pattern for six categories, and saying what they are doing. There are over 40 possible items the learner is retrieving from their long-term memory while using their working memory and regions of the brain which contain letters, numbers, pictures, sounds, directions, and colors. If the learners succeeded at a particular level of n, the task was made incrementally more difficult by increasing the size of n to six. Table 1 describes the exercises in the Brown 6 n-back while Figures 1-5 show examples of the exercises (12).

**Table 1. Brown Six N Back Equipping Minds Cognitive Development Curriculum**

Cognitive Functions Targeted	Exercise	Description
Visual processing, auditory processing, working memory, visual motor coordination, receptive and expressive language, visual spatial reasoning, abstract thinking, refraining impulsivity	Animals	Mediator states 1-2 directions ex: "I see you putting a circle around the one..." What do you see yourself doing? Learner replies, "I see myself putting a circle around the one" and performs the action. Use a page protector and dry erase marker.
Projection of relationships, comparisons, visualization, expressive language	Presidents "Yo Millard Filmore" Book	Describe the pictures of the presidents by stating the size, shapes, colors, objects, quantities, location, positions, and relationships. 1 Washington, 2 Adams, 3 Jefferson, 4 Madison, 5 Monroe, 6 JQ Adams, 7 Jackson, 8 Van Buren and continue to 45 Trump
Working memory, visual and auditory processing, long term memory, attention, expressive and receptive language, abstract thinking, visual motor coordination, refraining impulsivity, logic thinking	Numbers 1-5	Use a page protector and dry erase marker. First, place symbols and then cubes with corresponding number. Circle and green cube on 1, x and blue cube on 2, box and red cube on 3, yellow cube and underline 4, black cube and line above 5. Remove page protector and read symbols back by alternating saying the number. Then say number, color. Next, number, color, animal. Then, number, color, animal, letter. Finally, number, color, animal, letter, president: a 5 n back.
Working memory, visual and auditory processing, long term memory, attention, expressive and receptive language, abstract thinking, phonemic processing, refraining impulsivity, logical thinking, spontaneous comparison	Letters a-e	First, place symbols and then cubes with corresponding letter. Circle and green cube on a, x and blue cube one, box and red cube on i, yellow cube and underline o, black cube and line above u. Remove page protector and read symbols back by alternating saying the letter. Then say letter, and sound. Add letter, sound, color. Next, letter, sound, color, number. Then, letter, sound, color, number, animal Finally, letter, sound, color, number, animal, president: a 6 n back. Also do the 6 n back with the cubes covering the letters.
Spatial concepts of left, right, up, down, Inductive thinking, inductions of rules, seriation, working memory, long term memory, auditory and visual processing, abstract thinking, Systematic approach to new information and object, refraining impulsivity, logical thinking, spontaneous comparison	Colored Arrows	Say the direction of the arrow, then the color, then alternate color, direction. Add the corresponding number and say number, color, direction. Add the corresponding animal and say number, color, animal, direction. Add the corresponding letter and say the number, color, animal, letter, and direction. Add the president sequentially and say the number, color, animal, letter, president, and direction. Use a page protector and dry erase marker and put the symbol on each arrow while saying the number, color, animal, letter, president, and direction. Remove the page protector and read the symbols only saying the number, color, animal, letter, president, and direction. * Add an additional mark at the tip of the arrow when marking the direction. Now use the colored cubes and place them down while saying number, color, animal, letter, president, direction.

**Table 2. Equipping Minds mediation questions based on Feuerstein's cognitive functions and Aristotle's ten categories of being**

Collecting	Processing	Expressing
<ul style="list-style-type: none"> <li>• What or who do you see, hear, feel, taste, touch, and smell?</li> <li>• What can you visualize or imagine in your mind?</li> <li>• What do you see yourself doing?</li> <li>• What is the name of what you see or are thinking?</li> <li>• Where are you starting?</li> <li>• Do you have the correct materials?</li> <li>• What parts do you need, and what order will you need to follow to make the finished product?</li> <li>• What do you know to be true, or what is constant and does not change?</li> <li>• What is to your right? What is to my right?</li> <li>• If you are facing in this direction, what is to your right? Left? Front? Back? East? West? North? South? Northwest? Southeast?</li> <li>• When do you see this happening – past, present, future?</li> <li>• How long did the event occur? In what order did it happen?</li> </ul>	<ul style="list-style-type: none"> <li>• What am I to do?</li> <li>• Problem, what problem?</li> <li>• What do you need to figure out?</li> <li>• What is relevant to the problem?</li> <li>• What is needed, and what can be ignored/omitted?</li> <li>• What is similar?</li> <li>• What characteristics are different?</li> <li>• Consider: number, color, shape, size, direction, position, and feeling</li> <li>• What different categories do you see?</li> <li>• How are these related to each other?</li> <li>• Ask: What is your plan? What are the steps you will follow and the reasons?</li> <li>• Avoid trial and error! Have a plan.</li> <li>• Does this make sense?</li> <li>• If this is true, then what else must be true?</li> <li>• Are there different possibilities?</li> <li>• How can you see if this is true?</li> </ul>	<ul style="list-style-type: none"> <li>• What does the other person believe and why?</li> <li>• How does the other person feel?</li> <li>• Can you imagine how you would feel in their position?</li> <li>• How would the other person want to be viewed and treated?</li> <li>• Have you thought through what you want to say or write?</li> <li>• Are your words relevant to the situation?</li> <li>• Is your language clear to the audience?</li> <li>• Do you need to take a break and attempt later or tomorrow?</li> </ul>



Circle the Bear

Box the Snake

X the Fish

Underline the Elephant

Line above the Turtle

Figure 1. Animal.

<b>Basic US Presidents</b>
1. Washington green
2. Adams blue
3. Jefferson red
4. Madison yellow
5. Monroe black
<b>Advanced US Presidents are said sequentially for n –back</b>
6. Washington
7. Adams
8. Jefferson
9. Madison
10. Monroe
11. John Quincy Adams
12. Jackson
13. Van Buren
14. Harrison
15. Tyler
16. Polk
17. Taylor
18. Fillmore
19. Pierce

Figure 2. US presidents “Yo Millard Fillmore.”

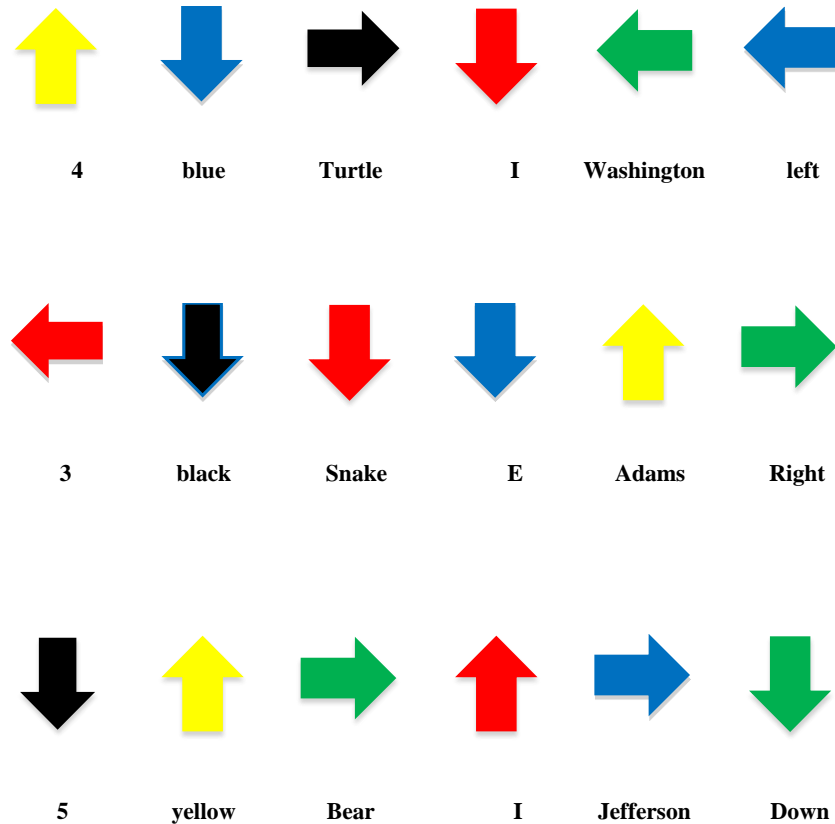
2 1 5 4 3 circle the 1 and place a green cube
5 3 5 4 1 X the 2 and place a blue cube
3 1 4 2 5 box the 3 and place a red cube
5 4 3 1 2 line under the 4 and place a yellow cube
4 2 5 3 1 line above the 5 and place a black cube

Figure 3. 1-5 Numbers.

e a u o i circle the a and place a green cube
u i e o a X the e and place a blue cube
i a o e u box the i and place a red cube
u o i a e line under the o and place a yellow cube
o e u i a line above the u and place a black

Figure 4. Letters a, e, i, o, u.





Say the number, color, animal, letter, president (sequentially), direction.

Use a page protector and dry erase marker say and mark the six items. Place a point at the tip of the arrow for the direction.

Remove the page protector and read the symbols: number, color, animal, letter, president (sequentially), direction.

Next, place the colored cubes down turned to match the direction of the arrow while saying the number, color, animal, letter, president (sequentially), direction.

Figure 5. Brown Six N Back.

## Case studies

This article will present five case studies of learners with a neurodevelopmental disorder. Brown utilized the following data collection techniques: clinical observations of the learners, examining and analyzing the psychological and educational documents, and interviewing the parents, the learners, and teachers.

### *Case 1. Joseph: Fetal alcohol syndrome, mixed expressive/receptive language disorder, developmental coordination disorder*

Joseph was adopted from Poland at five years of age and lives in the United States. He was removed from

his biological mother due to neglect and alcohol abuse. Joseph has fetal alcohol syndrome, a language processing disability with impairments in both expressive and receptive channels, and developmental coordination disorder.

### *Assessment*

At the age of 8 years, Joseph received an extensive evaluation of his cognitive abilities in 2015 and further evaluations in 2016 at 10 years of age. The evaluation procedures used included:

- Clinical observation sessions
- Interview with parents

- Woodcock Johnson-III Academic Skills Index
- Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV)
- Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V)
- Kaufman Brief Intelligence Second Edition (KBIT-2)
- Kaufman Test of Educational Achievement-3<sup>rd</sup> Edition-Form A
- Test of Variables of Attention (TOVA)

The examiners found him to be a sweet and softly spoken child, who seemed to have a gentle soul. He was polite and friendly, and displayed interest and curiosity about many of the tasks that were administered. The assessment found many other strengths, including:

- Exceptional academic abilities for a child of his age, with a performance at the 92nd percentile on the Woodcock Johnson-III Academic Skills Index, which includes measures of reading, writing, and math.
- Exceptional ability for doing simple reading, writing and math tasks with accuracy, speed and efficiency, with a performance at the 98th percentile on the Woodcock Johnson-III Academic Fluency Index.

It is very impressive that Joseph had such strong academic skills, which is a testament to his desire to work hard, as well as the support of his parents and teachers. It is the examiners impression that it is likely that school-based tasks are easier for him because they are familiar, and he is familiar with what he needs to do. More abstract and less context-rich tasks are much more likely to be challenging. The assessment found significant challenges in his cognitive development, which are likely to negatively impact his future learning as the curriculum becomes more demanding, and when there are higher expectations of independent working. These challenges need to be addressed, and include the following:

1. Very weak language processing skills, for both expressive and receptive language tasks,

as well as for simple language (i.e., vocabulary, syntax, and grammar) as well as complex language abilities (i.e., the ability to make inferences or to understand intention). The examiner believes that Joseph's difficulties are consistent with a diagnosis of a Mixed Expressive/Receptive Language Disorder (ICD 10: F80.1). This profoundly impacts his ability to learn in a classroom environment (i.e., receptive language) as well as severely limits his capacity to participate in class or group based activities (i.e., expressive language).

2. Very weak visual-spatial processing skills as well as poor fine-motor control, which is likely to profoundly impact his ability to learn, unless accommodations are made to support this challenge. His difficulties are consistent with a diagnosis of a Developmental Coordination Disorder (i.e., dysgraphia, ICD 10 Code: F82).
3. Some weakness for sustaining attention and executive functioning, that while likely to significantly impact his daily life at school, is likely to be related to the specific learning challenges described above. At this time, although these challenges would typically be indicative of an attention disorder, it is the examiners impression that his learning challenges are a better explanation for why he has weakness in tasks of Working Memory and Processing Speed.

Working Memory is the ability to hold information in your head to be used in that moment (e.g., remembering a telephone number). Joseph's performance was weak with a working memory index score of 80, which is the 13th percentile for the WISC-IV. Processing speed is the ability to quickly complete simple clerical-like tasks and is a measure of how efficiently a person is able to do the task. Joseph's performance was also in the 13th percentile for the WISC-IV for a processing index score of 83. However, it should be noted that on the more worldly and typical tasks of speed and efficiency, such as the reading, writing, and math fluency tasks of the Woodcock Johnson-III, Joseph's performance was incredibly strong at the 98th percentile.

### *Intervention*

In March 2015, Joseph's parents contacted Brown to discuss using *EMCDC* to strengthen his cognitive abilities; visual and auditory processing speed, comprehension, working memory, long term memory, and reasoning skills. According to Joseph's parents, despite all the support from Joseph's teachers, an occupational therapist, and a speech therapist, he was not able to work independently in class. Brown reviewed the academic and psychological testing showing cognitive deficits in processing, working memory, comprehension, and perceptual reasoning; she then agreed to begin working with Joseph using *EMCDC*. Joseph received cognitive developmental therapy with *Equipping Minds Cognitive Development Curriculum* from April 2015-January 2017 for 30-minute sessions, 5 days a week for 150 hours. During this time, he also did primitive reflex exercises and listened to sound therapy for a few months.

### *Results after intervention*

In December 2016, another psychological evaluation was given. Previously Joseph's working memory was an index score of 80, which is the 13<sup>th</sup> percentile. In contrast to the 2015 evaluation, the working memory index score increased to 103 and the 58<sup>th</sup> percentile in the average range. The Processing Speed is considerably higher on the 2016 evaluation increasing from an index score of 83 to 98 and from the 13<sup>th</sup> to 48<sup>th</sup> percentile in the average range.

In March 2017, the Kaufman Test of Educational Achievement-3<sup>rd</sup> Edition-Form A (KTEA-3) was administered. The KTEA-3 is comprised of subtests that measure a student's academic achievement in the areas of reading, written language, and math. Joseph is performing in the average range in all academic areas. When compared to grade norms, Joseph's scores are higher. While he demonstrated average comprehension abilities when reading expository passages and literal questions, he demonstrated weaknesses when reading fictional passages and answering inferential questions. Math concepts and applications are a relative strength for Joseph while math computations are a relative weakness. Joseph

performed equally well with written expression and spelling.

The current scores are in some way similar to previous results and in some ways dissimilar. The WISC-V has a differing format than the WISC-IV, which was used last year. With one exception, each of the index scores has at least one and sometimes two subtests within the average range, suggesting that Joseph's potential is at least in the average range in all of the tested areas, except for one. Joseph's Vocabulary score was in the middle of the average range. Vocabulary is the single best estimate of intelligence and based on that score, it would suggest that he has average intellect. However, as he did on the 2015 WISC-IV, he had extreme difficulty in understanding superordinate concepts. In other words, understanding the relationship to how things are similar. Another way of saying it would be that he had difficulty detecting the conceptual relationship among objects. In the 2015 report, Joseph had very poor visual spatial ability. However, on this measure, there is an addition of another subtest not given on the WISC-IV. On the Block Design subtest, which is a visual spatial task or a task of perceptual analytic reasoning, he scored in the average range (in 2015 he was in the low average range.). The same is true on a task in which he had to analyze and synthesize visual objects. The index score of 92 falls in the average range. Thus, visual spatial reasoning or perceptual analytic abilities are in the average range, albeit at the lower end of average.

Where Joseph had the most difficulty was in Fluid Reasoning. These tasks require him to detect underlying conceptual relationships among visual objects and then use reasoning to identify and apply the rules. Joseph had extreme difficulty. Similarly, as already mentioned, Joseph had difficulty understanding conceptual relationships on a verbal task (Similarities subtest). It should be noted that the examiner who administered the WISC V was not familiar to Joseph and noted significant impulsivity and anxiety during the testing.

However, at 10 years of age, Joseph was administered the Kaufmann Brief Intelligence- 2 (KBIT-2) in September 2016 by Brown who had been working with him on a daily basis for 1.5 years. The test was given over two days. Joseph exhibited no impulsivity or anxiety and was extremely thoughtful

in his responses. KBIT-2, a brief intelligence test which measures verbal and nonverbal intelligence for individuals from 4 to 90 years of age. The test 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). Joseph had a standard score of 102 in the 55<sup>th</sup> percentile and average range. 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 (17). Joseph had a standard score of 112 in the 79<sup>th</sup> percentile in the average range. The IQ composite had a standard score of 109 in the 73<sup>rd</sup> percentile also in the average range. This is the only examine administered by Brown. It is Brown's opinion that the difference in fluid reasoning scores on the WISC V and KBIT 2 are a result of the cognitive training and having a relationship with the examiner allowing Joseph to complete the test in optimum conditions.

In contrast to the 2015 evaluation, the Working Memory Index is in the 58<sup>th</sup> percentile and solidly in the average range. Both of the measures here are solidly average. Auditory short-term memory is

average and visual attention span is also in the average range. The Processing Speed Index also is considerably higher on the 2016 evaluation. His motor response to a visual perceptual task was relatively quick. However, when cognitive tasks are added to the task such as discrimination and scanning, he falters significantly. These gains demonstrate the impact of *EMCDC* on working memory and processing speed.

Furthermore, the psychological examiner notes the Full-Scale IQ cannot be used as a fixed figure. There are a number of indicators on the measure that would suggest average intellect. This would be in agreement with Brown's assessment on the KBIT-2 placing Joseph in the average range.

The Test of Variables of Attention (TOVA) was administered on December 2, 2016. The results are similar to those diagnosed with ADHD. The examiner recommended medication on a trial basis.

In conclusion, Joseph has shown strong cognitive modifiability throughout the program with *ECMDC*. He has an incredible work ethic and maintains a positive growth mindset. Joseph's visual and verbal memory, visual- spatial memory, and reasoning skills have developed significantly. He is giving more attention to detail, following 3-4 step directions, and verbalizing his thought process.

**Table 3. Results of WISC IV and WISC V of Joseph**

Scale WISC – IV 01-02/ 2015	Percentile	Composite Score	Scale WISC –V 12/2016	Percentile	Composite Score	Composite Difference
Verbal Comprehension	32 <sup>nd</sup>	93	Verbal Comprehension	18 <sup>th</sup>	86	-7
Working Memory	13 <sup>th</sup>	80	Working Memory	58 <sup>th</sup>	103	23
Processing Speed	13 <sup>th</sup>	83	Processing Speed	48 <sup>th</sup>	98	15
Perceptual Reasoning	14 <sup>th</sup>	84	Visual Spatial	30 <sup>th</sup>	92	8
			Fluid Reasoning	8 <sup>th</sup>	79	
			Full Scale IQ	21 <sup>st</sup>	88	

**Table 4. Results of KBIT -2 of Joseph**

Scale KBIT-2 02/2016	Standard Score	Percentile
Verbal	102	55
Nonverbal	112	79
IQ	109	73

**Table 5. Results of KETA-3 of Joseph**

Scale KETA-3 03/2017	Standard Score	Percentile
Reading Composite	99	47
Math Composite	96	42
Written-Language Composite	98	45

### *Case 2. David: Autism, apraxia, anxiety and Hashimoto's disease*

David is an eleven-year old boy with a diagnosis of Autism. His mother, a registered nurse, reported that at four months of age, David received the t-dap vaccine and “went limp” at that time. She noted that he had 104-degree fever and also began showing signs of hypotonia. He also reportedly had an undiagnosed salmonella infection at that time. He was diagnosed with Autism and verbal apraxia at two years, eight months of age. He was also diagnosed with Hashimoto's Disease in December of 2010. David's school performance is below average. He has received ABA therapy, speech therapy, and occupational services for many years. He struggles with anxiety, atypical social behavior, and preservation on topics.

### *Assessment*

At the age of 8, David received an extensive evaluation of his cognitive abilities in 2015 and further evaluations in 2016. The evaluation procedures used included:

- Clinical observation sessions
- Interview with parents
- Wechsler Individual Achievement Test-III
- Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV)
- Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V)
- Kaufman Brief Intelligence Second Edition (KBIT-2)
- Kaufman Test of Educational Achievement-3<sup>rd</sup> Edition-Form A

In 2015 the processing speed index (PSI) of the WISC IV was given to David with a PSI of 73. The Kaufmann Brief Intelligence- 2 (KBIT-2) was also given in 2015. 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). David had a standard score of 61 in the below average range. 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 (17). David had a Nonverbal standard score of 66 in the below average range. The IQ composite had a standard score of 58 also in the below average range.

The Wechsler Individual Achievement Test-III was given to David in 2015. The examiner noted severe difficulties academically with severely impaired scores in early reading, math problem and listening comprehension. Spelling was in the low average range and alphabet writing in the average range. Word reading and numerical operations were in the moderately impaired range. David made significant gains in reading abilities.

### *Intervention*

In December 2014, David's parents contacted Brown to discuss using *EMCDC* to strengthen his cognitive abilities; visual and auditory processing speed, comprehension, working memory, long term memory, and reasoning skills. According to David's parents, despite all the support from teachers, occupational therapist and speech therapist his IQ composite was a 58 showing an intellectual disability. 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 David using *EMCDC*. David has received cognitive developmental therapy with *Equipping Minds Cognitive Development Curriculum* from February 2015- May 2017 for 20-30 minute sessions, 5 days a week for 160 hours.

### *Results after intervention*

In September 2016, David was referred for a psycho-educational re-evaluation to determine continued special education eligibility and placement. He was previously identified as a student with an Autism Spectrum Disorder. He had most recently attended private school. With his recent move into the public school, a psychological and educational assessment was done in the first month of school. David was seen for one assessment session. Though David had no relationship with the examiner, rapport during testing was easy to establish and maintain. He was a willing and cooperative test participant, although quiet at the beginning. David was generally polite and responsive to the examiner and worked steadily on those tasks that were presented to him. During the testing situation, David utilized a moderate work pace. He maintained inconsistent eye contact and displayed decent interpersonal skills. He was persistent on most tasks and showed some interest in the tasks presented. David displayed a normal activity level for his age. He responded with realistic confidence in his ability, not becoming overly upset or frustrated when a question or task was perceived as challenging / difficult. David required some encouragement throughout testing. He tended to respond with general or vague responses and benefitted from queries to improve upon his answers. Visual tasks that included a model were particularly beneficial. Overall, the results of this evaluation are considered to be a valid indication of David's current potential and general levels of ability.

After receiving cognitive intervention with *EMCDC* for 1.5 years, the *WISC-V* was given in 2016 to assess David's performance across five areas of cognitive ability. As measured by the *WISC-V*, his overall *FSIQ* score fell in the Below Average range when compared to other children his age (*FSIQ* = 72).

However, this was an increase of 14 points from the *FSIQ* of 58 in 2015. Furthermore, he showed average performance when working with primarily visual information and the *VSI* demonstrates an area of strength relative to his overall ability (*VSI* = 97). When compared to his fluid reasoning (*FRI* = 85), working memory (*WMI* = 74), and processing speed (*PSI* = 77) performance, visual spatial skills emerged as a particular strength.

The language skills assessed appear to be one of David's lowest areas of functioning. He showed very weak performance on the Verbal Comprehension Index (*VCI* = 62). The verbal results are similar to the 2015 *KBIT-2* with a score of 66. Verbal scores emerged as an area of need when compared to his performance on fluid reasoning (*FRI* = 85), working memory (*WMI* = 74), and processing speed (*PSI* = 77) tasks. Ancillary index scores revealed additional information about David's cognitive abilities using unique subtest groupings to better interpret clinical needs. On the Nonverbal Index (*NVI*), a measure of general intellectual ability that minimizes expressive language demands, his performance was Below Average for his age (*NVI* = 82). He also scored in the Below Average range on the General Ability Index (*GAI*), which provides an estimate of general intellectual ability that is less reliant on working memory and processing speed relative to the *FSIQ* (*GAI* = 75). David's low performance on the Cognitive Proficiency Index (*CPI*) suggests that he struggles to efficiently process cognitive information in the service of learning, problem solving, and higher order reasoning (*CPI* = 73). David achieved an average score on the *VMI*, which measures visual motor integration skills.

However, at 10 years of age, David was administered the Kaufmann Brief Intelligence- 2 (*KBIT-2*) in September 2016 by Brown who had been working with him on a daily basis for over 1.5 years. The test was given over two days. David exhibited no anxiety and was extremely thoughtful in his responses. The *KBIT-2*, measures verbal and nonverbal intelligence for individuals from 4 to 90 years of age. The test 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). David had a verbal standard score of 69 in the 8<sup>th</sup> percentile and in the below average range. This score was similar to his verbal comprehension index score of 62 on the WISC V and the verbal score on the KBIT -2 in 2015 of 61. 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 (17). David had a standard score of 122 in the 56<sup>th</sup> percentile in the average range which is a substantial gain of 56 points from the 2015 KBIT-2 with a Nonverbal score of 66. As noted on the WISC V, David's visual spatial skills emerged as a particular strength with a score of 97. The IQ composite had a standard score of 95 in the 37<sup>th</sup> percentile also in the average range. This is the only exam administered by Brown. It is Brown's opinion that the difference in IQ on the 2016 WISC V (FSIQ-72), 2015 KBIT 2 (FSIQ-58), and 2016 KBIT 2 (FSIQ 95) are a result of the cognitive training and having a relationship with the examiner allowing David to complete the test in optimum conditions.

Results of standardized achievement testing on the Kaufman Test of Educational Achievement-3<sup>rd</sup> Edition-Form A given in 2016 suggest that David is performing within the average range for the area of spelling. The areas of letter/word recognition, silent reading fluency, reading comprehension, math computation, and math concepts/applications were found to be within the below average range. The assessment instruments used provide a comprehensive set of individually administered norm-referenced tests

for measuring academic achievement. It should be noted that norm-referenced assessments do not test curriculum benchmarks or the amount of instruction needed to achieve benchmarks. These tests provide a measure of David's academic achievement as compared to same age peers using a standard score. His test performance can be generalized to similar, non-test, age-level tasks.

In analyzing the results on the Wechsler Individual Achievement Test-III given in 2015 and the Kaufman Test of Educational Achievement-3<sup>rd</sup> Edition-Form A given in 2016, David made significant gains in reading abilities, letter / word recognition, silent reading fluency, reading comprehension, math computation, and math concepts / applications moving from severely impaired in 2015 to below average range 1.5 years later. Spelling moved from below average to the average range.

In conclusion, the academic and cognitive gains which David has shown indicate strong cognitive modifiability in many areas. While the verbal skills have not increased at the same rate as the Nonverbal, nonetheless, there has been progress. Brown would note that whereas the processing scores are in the below average range, David is very diligent and precise when completing processing exercises. He is typically 100% accurate but works slowly. Brown was not surprised by the slower processing score. David continues to increase in his reading abilities, writing, and enjoys cognitive exercises which employ visual logic puzzles.

**Table 6. Results of WISC IV, WISC V, and KBIT-2 of David**

Scale WISC – IV 01/2015	Composite Score	Scale WISC –V 09//2016	Composite Score	Difference	
		Verbal Comprehension	62		Below Average
		Working Memory	74		Below Average
Processing Speed	73	Processing Speed	77	4	Below Average
		Visual Spatial	97		Average
		Fluid Reasoning	85		Average
KBIT-2 IQ Composite	58	Full Scale IQ	72	14	Below Average

**Table 7. Results of KBIT 2 of David**

KBIT-2 01/2015	Standard Score	KBIT-2 09/2016	Standard Score	Difference	
Verbal	61	Verbal	69	8	Below Average
Nonverbal	66	Nonverbal	122	56	Average
IQ Composite	58	IQ Composite	95	37	Average

**Table 8. Results of WIAT III of David**

Scale WIAT-III 01/2015	Standard Score	Scale KETA-3 09/2016	Standard Score	Difference
Early Reading Skills	40	Reading Composite	73	33
Word Reading	70	Letter and Word Recognition	77	7
Listening Comprehension	53	Reading Comprehension	71	18
Receptive Vocabulary	66	Silent Reading Fluency	78	12
Expressive Vocabulary	55	Math Composite	73	18
Math Problem Solving	51	Math Concepts and Application	68	17
Numerical Operations	71	Math Computation	81	10
Spelling	83	Spelling	86	3

### *Case 3. Kay: General learning disorder*

Kay was born six weeks early with respiratory distress syndrome. She weighed less than six pounds, walked at 19 months, and began speaking between 30-36 months. Her parents have been concerned about her cognitive abilities since the first evaluation when she was 7 years of age. At that time, her Full-Scale IQ on the WISC-IV was 72. Kay performed much better on nonverbal than verbal reasoning tasks. Her Verbal Comprehension Index is 79, Perceptual Reasoning is 94, Processing Speed is 73, and Working Memory 56. Kay performs better on nonverbal than verbal skills.

At the age of 15 years, Kay had another educational evaluation. On the Slosson Full – Range Intelligence test, Kay received a Full –Range IQ score of 85. The verbal index score was 88, the memory index standard score is 80, and the performance index standard score is 84. All three of these index scores: 88, 84, and 80 are consistent with Kay’s overall IQ score of 85.

Academic testing has been done with the Woodcock Johnson Test of Achievement III (WJ-III) from 2005- 2016. In April 2005, the WJ-III results indicated Kay was in the average range in broad math and math calculations. Oral expression, basic reading,

and math reasoning, and listening comprehension were in the low average range. She has been home-schooled by her mother for her academic career. In 2013, the Peabody Individual Achievement Test was given. Kay had a standard score of 84 (14<sup>th</sup> percentile) in general information, standard score of 71 (3<sup>rd</sup> percentile) in reading recognition, a standard score of 70 (2<sup>nd</sup> percentile) in reading comprehension, standard score of 67 ( 1<sup>st</sup> percentile) in total reading, standard score of 74 (4<sup>th</sup> percentile) in mathematics, standard score of 76 (5<sup>th</sup> percentile) in spelling, stand score of 69 ( 2<sup>nd</sup> percentile) for the total test, a standard score of 71 (3<sup>rd</sup> percentile) in written language, and written expression was in the low range.

### *Assessments*

- Universal Nonverbal Intelligence Test (UNIT)
- WISC-IV
- Slosson Full Range IQ Test
- Woodcock-Johnson Tests of Achievement - Third Edition (WJ-III)
- Peabody Individual Achievement Test



### Intervention

In July 2015, Kay's parents contacted Brown to discuss using *EMCDC* to strengthen her cognitive abilities; visual and auditory processing speed, comprehension, working memory, long term memory, and reasoning skills. Kay is 17 years of age. According to Kay's mother, she was struggling to process information in a one-on-one homeschool setting. Brown reviewed the academic and psychological testing showing cognitive deficits in processing, working memory, comprehension, and perceptual reasoning; she then agreed to begin working with Kay using *EMCDC*. Kay received cognitive developmental therapy with *Equipping Minds Cognitive Development Curriculum* from September 2015- May 2016 for 30 minute sessions, 5 days a week for 60 hours.

### Results after intervention

After completing 60 hours with *EMCDC*, Kay took the Woodcock Johnson Test of Achievement III as she does every year. In analyzing the results from 2010-2014, Kay typically made gains of 6 months to 1 year. At a 9.8 grade level in 2014, Kay's scores ranged from 4.2 – 7.0 in the majority of subjects putting her 2 to 5 years below grade level. However, Kay made significant gains in Grade Equivalent (GE)

and Age Equivalent (AE) on the 2016 assessment where she was 11.8 GE and 18.2 AE in the following areas:

- Oral language went from a 4.4 GE to >17.6 GE for a gain of 13.2 years and >21 AE
- Written expression went from 7.6 GE to 12 GE for a gain of 4.4 years and >17.6 AE
- Understanding Directions which is similar to working memory went from 4.5 GE to 18 GE for a gain of 13.5 years and >21 AE
- Math Calculations went from 9.5 GE to 11.2 GE for a gain of 1.7 years and 16.8 AE
- Writing Sample went from 8.7 GE to 11.4 GE for a gain of 2.7 years and 16.11 AE
- Story Recall went from 5.6 GE to 13 GE for a gain of 7.4 years and 20 AE.

The same examiner has given the test for numerous years and indicated that gains of this magnitude had not been seen and is untypical of someone with Kay's long academic history of learning challenges. The gains correspond with the cognitive developmental therapy with *EMCDC* which Kay received during September 2015-May 2015. She had previously been receiving academic tutoring alone. In conclusion, the academic gains which Kay has shown indicate strong cognitive modifiability in many areas after using *EMCDC*.

**Table 9. Results of WISC IV for Kay**

Scale WISC –V 12/2005	Composite Score	Percentile	
Verbal Comprehension	79	8	Low
Working Memory	56	.2	Low
Processing Speed	73	4	Low
Perceptual Reasoning	94	34	Average
Full Scale IQ	72	3	Low

**Table 10. Results of Slosson for Kay**

Scale 03/2013	Composite Score	Percentile	
Verbal Index	88	8	Low
Memory Index	80	.2	Low
Performance Index	84	4	Low
Full Scale IQ	85	3	Below Average

**Table 11. Results of Universal Nonverbal Intelligence Test (UNIT) for Kay**

UNIT 05/2006	Standard Score	Percentile
Memory Quotient	89	23
Reasoning Quotient	95	37
Symbolic Quotient	91	27
Non-symbolic Quotient	93	32
Full Scale IQ	91	I

**Table 12. Results Woodcock Johnson III Normative Tests of Achievement of Kay**

	GE:5.8	GE:6.8	GE:7.8	GE:9.8	Score after Intervention Grade: 11.8	Difference
	2010	2011	2012	2014	2016	
Oral Language	3.7	3.5	4.6	4.4	17.6	13.2
Brief Achievement	3.2	3.7	4.2	4.6	6.5	1.9
Broad Reading	2.8	3.1	3.9	4.7	6.6	1.9
Broad Math	5.2	5.7	6.3	7	7.2	0.2
Broad Written Language	3.3	4.3	4.8	6.3	8.9	2.6
Brief Reading	2.9	3.3	4.1	4.8	7	2.2
Brief Math	5.1	5.5	6.3	6.6	7.2	0.6
Math Calc. Skills	6	6.4	8.1	9.2	9.2	0
Brief Writing	3	4.1	4.7	5.9	8.1	2.2
Written Expression	3.9	5.1	5.5	7.6	12	4.4
Acad. Skills	3.6	4	5.1	5.5	7.8	2.3
Acad. Fluency	3.6	4.3	4.7	6.4	7.6	1.2
Academic Apps	3.6	4.5	4.7	5.9	6.7	0.8
Academic Knowledge	3.4	3.4	4.5	4.8	7.1	2.3
Letter Word ID	3	3.2	4.2	4.3	7.2	2.9
Reading Fluency	2.4	2.4	3.2	4.3	5.5	1.2
Story Recall	3	8.8	3.7	4.2	6.8	2.6
Understanding Directions	4.1	2.4	5.1	4.5	18	13.5
Calculations	6.4	6.4	9.5	9.5	11.2	1.7
Math Fluency	5.4	6.7	6.6	8.7	7.5	-1.2
Spelling	2.7	3.4	3.7	4.8	6.9	2.1
Writing Fluency	3.9	4.9	4.9	7	13	6
Passage Com	2.7	3.5	3.9	6	6.7	0.7
Applied Prob.	4.2	4.7	4.5	4.8	5.2	0.4
Writing Sample	3.8	5.5	6.7	8.7	11.4	2.7
Story Recall	1.8	17.8	2.7	5.6	13	7.4
Academic Knowledge	3.4	3.4	4.5	4.8	7.1	2.3

*Case 4. Steven: Fetal alcohol spectrum disorder, post-traumatic stress disorder, autism, mixed receptive-expressive language disorder, specific learning disorder, anxiety*

Steven was adopted from Russia at 5 years of age. He has a history of mild alcohol related neuro-developmental disorder in addition to psychosocial

growth failure. He has been evaluated by a pediatric endocrinologist for growth issues as he has been below the 10<sup>th</sup> percentile which was consistent with the initial neuropsychological evaluation. Steven is on medication for attentional problems and has Lyme disease. He has a history of strabismus with residual exotropia which was addressed in developmental optometry. The diagnostic conclusions indicated

a mixed receptive-expressive language disorder; multi-sensory neuropsychologically-based processing deficits related to an alcohol related neurodevelopmental disorder/static encephalopathy in addition to multiple learning disabilities in the category of developmental dyslexic disorder. Steven certainly had a great deal of anxiety which is very commonly seen in children who have multi-sensory neuro-cognitive deficits.

Steven's overall neuropsychological history indicates that he was evaluated at the age of 10 years of age with a pattern of global weaknesses in receptive and expressive language as well as processing and learning deficits. Many of these issues were related to mild alcohol-related neurodevelopmental disorder with some quasi-autistic characteristics in addition to multisensory information processing impairments. Subsequent to the neuropsychological evaluation, Steven received special education services throughout his school years and was re-evaluated at the start of his tenth-grade year in January of 2012.

### *Assessments*

Steven received extensive evaluations of his cognitive abilities from 2005-2015. The evaluation procedures used included:

- Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV)
- Childhood Autism Rating Scale – Second Edition (CARS) (Higher-Functioning Version)
- Gilliam Autism Rating Scale – Third Edition (GARS)
- Test of Visual-Perceptual Skills – Third Edition
- Test of Auditory Processing Skills – Third Edition
- Test of Adolescent and Adult Language – Fourth Edition
- Wide Range Achievement Test – Fourth Edition (WRAT-4)
- Wechsler Individual Achievement Test – Third Edition (WIAT-III)
- Wechsler Memory Scale – Fourth Edition
- Cognitive Assessment System

- Category Test
- Wisconsin Card Sorting Test
- Thematic Apperception Test
- Minnesota Multiphasic Personality Inventory – Second Edition (MMPI-2)
- Adult and Family Sentence Completion Series
- Adult Neuropsychological History
- Adult Neuropsychological Questionnaire
- Review of Records

Steven's initial intellectual testing completed in 2005 yielded a Verbal Comprehension IQ Score of 75; Perceptual Reasoning IQ Score of 92; Working Memory IQ Score of 77; Processing Speed IQ Score of 97; Full Scale IQ Score of 81. All of these scores are generally within the Average Range. Gaps and inconsistencies in nonverbal learning aptitudes and abilities as well as receptive and expressive language were evident.

In the updated evaluation in 2012, Steven was administered the Wechsler Intelligence Scale for Children – Fourth Edition and obtained a Verbal Comprehension IQ Score of 79 (Borderline Range); Perceptual Reasoning IQ Score of 88 (Low-Average Range); Working Memory IQ Score of 83.

Steven also showed ongoing indications of a mild Autistic Disorder given his difficulties in relating to others as well as anxiety, stress and struggles with adapting to change, in addition to expressive pragmatic language. Steven also had definite problems in comprehension and higher-level listening responses in addition to gaps and inconsistencies in attention, memory, learning and overall information processing and problem solving.

Steven's overall language abilities indicated major weaknesses in comprehension, processing and expressive semantic-pragmatic-syntactical expression. Academic-achievement abilities indicated weaknesses in reading style, rate and written language with relative strengths in mechanical math but difficulties in mental calculations and word problems. Steven always struggled with expressive writing in addition to memory processing and consolidation in both auditory and visual spheres. He also had significant patterns of executive dysfunction. Over the years,

Steven has been receiving special education services through his school district and has made gradual progress.

### *Intervention*

In October of 2014, Steven's parents contacted Brown to discuss using *EMCDC* to strengthen his cognitive abilities; visual and auditory processing speed, comprehension, working memory, long term memory, and reasoning skills. According to Steven's parents, he was finishing his senior year in high school and continuing to struggle in social awareness, math sense, communication skills, executive functioning, and academics. Brown reviewed the academic and psychological testing showing cognitive deficits in processing, working memory, comprehension, and perceptual reasoning; she then agreed to begin working with Steven using *EMCDC*. Steven received cognitive developmental therapy with Equipping Minds Cognitive Development Curriculum from January 2015-May 2015 for 60 minute sessions 5 days a week for 60 hours. Steven also did 15-20 minutes of primitive reflex integration therapy and 60 minutes of sound therapy on a daily basis for a few months.

### *Results after intervention*

After completing cognitive developmental therapy with *EMCDC*, his parents stated that Steven showed reduced anxiety, increased eye contact, more social awareness, had a sense of humor and math sense. His overall language and language arts abilities have improved with cognitive therapy, and he is definitely improved in his overall high school performance even though there are some gaps and inconsistencies in memory, learning and overall speech and language and pragmatics. Steven did begin a job working at a plant nursery where he can use his landscaping skills.

Further testing was done in July 2015. Steven remembered the examiner quite well and was very polite and cooperative. He displayed very good attention, concentration and focus as there were no major difficulties evident. Steven no longer needs to

take ADHD medication. Psychologically, Steven is a hands-on visual assimilative learner and is much more reality-based. Steven does much better with hands-on mechanical aptitude skills. He has developed better social reciprocity but still has some food selectivity as well as some subtle self-stimulatory behaviors. There are times that he can be rather rigid and inflexible in his thinking and easily overstimulated.

There were certainly some indications of ongoing "performance anxiety" which impacts testing. Steven continued to work very hard at all times but had the most struggles with higher-level language processing and lengthy and sequential memory, learning and recall which are longstanding issues and directly related to his low-grade Alcohol-Related Neurodevelopmental Disorder in addition to his mild autistic patterns.

Steven was administered the Wechsler Adult Intelligence Scale – Fourth Edition and showed a more stable pattern in his overall intellectual abilities which are now within the Average Range although he has a 21-point discrepancy between verbal comprehension and perceptual reasoning which indicates an ongoing language weakness pattern. He also has ongoing weaknesses in his expressive communications as he is not always clear and connected in his semantic-pragmatic-syntactical expression.

As a general summary statement, there is no question that Steven has improved on a global perspective in terms of neurocognitive or neuropsychiatric functioning. He is much more alert, oriented, interactive as well as motivated to do well with a lessening of the neurocognitive effects of a fetal alcohol spectrum disorder in addition to his autistic spectrum disorder which has always been at the "higher-functioning spectrum." In terms of pure academic-achievement abilities, Steven is at the middle school level in overall reading, reading comprehension, spelling and written language and mathematics. This certainly is a significant improvement as it shows that he has enough neurocognitive and academic skills in order to function at the technical-vocational training level as his strengths are in the areas of hands-on visual assimilative learning which is his area of interest.

**Table 13. Results of WISC IV for Steven**

Scale WISC – IV 01/2012	Composite Score	Scale WISC –IV 07/2015	Composite Score	Difference
Verbal Comprehension	79	Verbal Comprehension	76	-3
Working Memory	83	Working Memory	80	-3
Processing Speed	94	Processing Speed	106	12
Perceptual Reasoning	88	Perceptual Reasoning	97	9
Full Scale IQ	81	Full Scale IQ	89	8

### *Case 5. Bryant: Post traumatic concussion syndrome*

At 18 years of age Bryant experienced a head injury during a rugby game. The doctors recommended antidepressants and extended rest. As the symptoms increased, he tried various treatments over the next four years from acupuncture to chiropractic treatments. However, the symptoms were not alleviated. He then took one year off and had given up. At this time, he was 23 years of age.

#### *Assessment*

- Interview with learner
- Learning Screening Checklist
- Primitive Reflex Checklist

Below is a list of the most prominent symptoms Bryant experienced after the concussion.

- Foggiess: One of my most prominent symptoms is what can only be described as a feeling of foggiess. When in this state, it is hard to complete most mental tasks. It felt as if my neurons were trying to fire and make connections but didn't have a clear pathway to do so according to Bryant.
- Difficulty with concentration and attention: Within this state Bryant had a difficult time concentrating on tasks and paying attention for extended periods of time.
- Poor working memory: Difficulty following multiple step directions
- Long term memory retrieval: Difficulty remembering names of people

- Language retrieval and processing: Difficulty recalling vocabulary
- Extreme physical and mental fatigue: Mental fatigue is like the foggiess but manifests itself in fatigue-like symptoms. For example, during reading Bryant would have to fight off an intense desire to sleep and could no longer concentrate on whatever was being read.
- Depression

#### *Intervention*

In October of 2016, Bryant contacted Brown to discuss using *EMCDC* to strengthen his cognitive deficits as a result of Post Traumatic Concussions Syndrome. According to Bryant he has tried numerous interventions over the last 5 years with little relief. Brown agreed to have an *EMCDC* mediator begin working with Bryant using *EMCDC*. Bryant received cognitive developmental therapy with *EMCDC* from September 2016-April 2017 for 30-60 minute sessions 5 days a week for 100 hours. Bryant also did 15-20 minutes of primitive reflex integration therapy and 60 minutes of sound therapy on a daily basis during this time.

#### *Results after intervention*

- Decreased foggiess: After working with *EMCDC*, the periods and intensity of foggiess have significantly decreased. The exercises we focused on strengthened those connections and helped my brain work around its deficits according to Bryant.

- Increased concentration and attention: Bryant reports having a much easier time holding attention and concentrating on specific tasks.
- Increase in working memory: Able to follow multi-step directions
- Long term memory: Able to store information and retrieve information much easier
- Increased stamina and energy: His stamina and energy has significantly improved while performing cognitive task.
- Enjoying reading and learning
- Spending extended time outside without being symptomatic

## Discussion

In the case studies, Brown examined the effects of *EMCDC*, a holistic cognitive development program, with children and adults in a one-on-one setting. Brown utilized clinical observations of the learners, examination and analyzation of the psychological and educational documents, and interviews with the parents, the learners, and teachers. Cognitive and academic gains were demonstrated in all of the case studies. The results are consistent with the results of Brown's doctoral research with learners with a Specific Learning Disorder and the four-year case study with Marie who had Down syndrome. Family members, therapists, and teachers were included in the therapy sessions and instructed how to interact and instruct using mediated learning. This suggests that a comprehensive intervention program which addresses numerous cognitive functions and includes parents and other professionals in the learner's life allows more opportunities for modification.

## Conclusion

While the case studies showed cognitive gains in each learner, case reports lack the strength of a controlled quantitative research study. However, single case research is accepted in neurorehabilitation scientific literature for neurodevelopmental disorders. The case histories suggest the importance of further

research with learners with neurodevelopmental disorders such as Fetal Alcohol Syndrome and Autism as well as Post Traumatic Concussion Syndrome using the *Equipping Minds Cognitive Development Curriculum (EMCDC)*. When implementing the *EMCDC*, it is essential to implement the program with fidelity using mediated learning. The success of the doctoral research with *EMCDC* and the case studies suggest that cognitive skills can be developed in the classroom or clinical setting through a human mediator which will increase verbal, nonverbal, IQ, and impact academics.

## Ethical compliance

The authors have stated all possible conflicts of interest within this work. The authors have stated all sources of funding for this work. If this work involved human participants, informed consent was received from each individual. If this work involved human participants, it was conducted in accordance with the 1964 Declaration of Helsinki. If this work involved experiments with animals, it was conducted in accordance with the related institutions' research ethics guidelines.

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*Submitted:* April 22, 2017. *Revised:* May18, 2017.  
*Accepted:* May 25, 2017.





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