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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 (1921-2014)

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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 the 32 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,* 2nd 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 the pre-test the participant's 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 2nd 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 2nd-12th grade students in reading, mathematics, language, science, social studies, and spelling. The *TerraNova* is a respected and valid national achievement test for reading, mathematics, language, science, social studies, and spelling. *TerraNova* features 2011 norms from a national study. These are the most current and accurate norms, which allow educators to compare achievement results between groups of students. With item alignments to state standards, educators can review student results in the context of common school and district criteria (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	$t_{(15)}$	Pre-to-Post (p)	M	$t_{(15)}$	Pre-to-Post (p)
Reading	0.250	0.324	.7508	1.069	2.249	.0399 *
Vocabulary	0.150	0.204	.8411	0.806	1.241	.2336
Language	1.081	1.674	.1148	1.169	1.722	.1055
Mechanics	-0.594	-0.754	.4624	1.131	1.498	.1549
Math	0.819	1.622	.1256	0.500	1.191	.2521
Computation	0.775	1.449	.1679	-0.113	-0.234	.8181
Science	0.019	0.032	.9745	1.438	4.050	.00105 **
Social Studies	0.844	1.260	.2268	0.950	1.239	.2345
Spelling	0.656	1.361	.1935	1.875	3.735	.00199 **

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

Table 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^2
Verbal WM	5.714 (2.396)	.0247 *	-0.0973 (5.200)	.9852	.1941
Visuospatial WM	-6.604 (4.311)	.1377	8.748 (9.358)	.3585	.2020
Reading	-0.127 (0.903)	.8893	4.345 (1.959)	.0355 *	.1901
Vocabulary	0.805 (1.049)	.4496	-1.613 (2.276)	.4849	.0547
Language	0.206 (0.941)	.8282	3.815 (2.043)	.0731 #	.1526
Mechanics	0.366 (1.117)	.7456	-0.517 (2.424)	.8326	.1877
Math	-0.056 (0.653)	.9318	2.319 (1.418)	.1141	.1744
Computation	-0.281 (0.770)	.7186	0.161 (1.671)	.9240	.0835
Science	-0.552 (0.651)	.4047	2.886 (1.413)	.0514 #	.3242
Social Studies	0.030 (1.056)	.9777	0.787 (2.291)	.7338	.0974
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 39th 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.

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