

Original Paper

Application of Brain-Based Teaching Strategies on Academic Performance of Children with Attention Deficit Hyperactivity Disorder (ADHD) In Mathematics

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Abstract

This study examined application of Brain-based Teaching Strategies on academic performance of children with ADHD in Mathematics. Gender and Mathematics anxiety level were introduced as moderator variables. A pre-test, post-test, control group experimental design was employed for this study. Two groups were involved (experimental and control groups). The experimental group was exposed to the application of Brain-based Teaching Strategies while the control group was exposed to the conventional method. Two instruments were used (i) Achievement Test in Mathematics (ATM) ($r = 0.83$) and (ii) Mathematics Anxiety Rating Scale (MARS) ($r = 0.80$). Data obtained were analyzed using descriptive statistics of means scores and standard deviations to explain and compare pretest and posttest mean scores of the experimental and control groups in all the criteria measured. Inferential

of various factors on the dependent variables. Treatment was more effective at improving children with ADHD attitude to mathematics than the conventional method. Findings indicated significant improvement on children’s attention span resulting from taking cognizance of “prime times” in the teaching-learning episode. Also, tension that is normally associated with the teaching-learning process of mathematics was significantly reduced.

Keywords

brain-based, attention deficit hyperactivity disorder, math anxiety

1. Introduction

Research evidence shows that many children exhibit diverse abnormal behaviors which include perceptual, visual hyperactivity disorders of memory and inattention. This category of children is easily distracted or carried away from a main focal activity at a time either during classroom interaction or any given task. Hyperactivity is the result of inadequate attention span; it is the inability to focus attention selectively on one major aspect of a situation. Children having the problem of short attention span exhibit behaviors that can either distract them or others, cannot

concentrate on any work at hand and a child with this deficit is always at the mercy of environmental stimuli (Friend, 2018; Schonwald, & Lechner, 2006). This type of children cannot focus their attention to the appropriate stimuli, they are unable to select which stimuli to concentrate and which to ignore. They have short attention span, their interest changes rapidly, they can happily start a task, but have difficulty in completing it. Stroubek, Kelly, and Li (2013) pointed out that Attention Deficit Hyperactivity Disorder (ADHD) is a mental neurodevelopment type. Walitza, Drechsler, and Ball (2012) observed that it is characterized by problems of paying attention, excessive activity or difficulty controlling behavior, which is not appropriate for a person's age. Evidently, problems emanating from paying attention among children may result in poor performance. It is discovered that many children with ADHD have a good attention span for tasks they find interesting.

Children with ADHD also have difficulty maintaining positive peer relationships. They tend to struggle with appropriately regulating their emotions in peer and social situations (Hoza, 2007). Therefore, peer rejection can occur, which leads to additional behavior problems. "It is estimated that between 50 and 80% of primary school children with ADHD can be considered peer-rejected, compared to 10-15% of typically developing boys and girls" (Kok, Groen, Fuermaier, & Tucha, 2016) Because of the increased impulsivity, distractibility, and inattentiveness, initiating and maintaining peer relationships can be difficult for children with ADHD, which can give them a more pessimistic view of their social world (Grygiel, Humenny, Rebisz, Bajcar, & Switaj, 2014).

Despite being the most commonly studied and diagnosed mental disorder in children and adolescents, the exact cause is unknown in the majority of cases. Research findings indicate that it affects about 5–7% of children when diagnosed via the DSM–IV criteria and 1–2% when diagnosed via the ICD–10 criteria (Cowen, Philip, Harrison, Paul, Burns, & Tom, 2012). In Mayor (2015), the results of a large national study of parental reports of an ADHD diagnosis claimed twelve percent of children and teens had a diagnosis of ADHD in 2011, showing an increase of 43% since 2003. ADHD is diagnosed approximately three times more often in boys than in girls, although the disorder is often overlooked in girls due to their symptoms differing from those of boys (Emond, Joyal, & Poissant, 2009). It is also to be noted that about 30–50% of people diagnosed in childhood continue to have

symptoms into adulthood and between 2–5% of adults have the condition (Ginsberg, Quintero, Anand, Casillas, & Upadhyaya, 2014). The condition can be difficult to tell apart from other disorders, as well as to distinguish from high levels of activity that are still within the normal range. Most healthcare providers accept ADHD as a genuine disorder in children and adults, and the debates in the scientific community mainly centers on how it is diagnosed and treated (Schonwald & Lechner, 2006).

1.1 Signs and Symptoms

Inattention, hyperactivity (restlessness in adults), disruptive behavior, and impulsivity are common in ADHD (CDC, 2016). The symptoms can be difficult to define, as it is hard to draw a line at where normal levels of inattention, hyperactivity, and impulsivity end and significant levels requiring interventions begin. American Psychiatric Association (2013) reported that according to the DSM–5, symptoms must be present for six months or more to a degree that is much greater than others of the same age and they must cause significant problems functioning in at least two settings (e.g., social, school/work, or home). The full criteria must have been met prior to age 12 in order to receive a diagnosis of ADHD.

ADHD is divided into three subtypes: predominantly inattentive (ADHD–PI or ADHD–I), predominantly hyperactive/Impulsive (ADHD–PH or ADHD–HI), and combined type (ADHD–C). A child with ADHD inattentive type has most or all of the following symptoms, excluding situations where these symptoms are better explained by another psychiatric or medical condition (American Psychiatric Association, 2013).

- Be easily distracted, miss details, forget things, and frequently switch from one activity to another.
- Have difficulty maintaining focus on one task.
- Become bored with a task after only a few minutes, unless doing something enjoyable.
- Have difficulty focusing attention on organizing and completing a task or learning something new.
- Have trouble completing or turning in homework assignments, often losing things (e.g., pencils, toys, assignments) needed to complete task or activities.
- Seem to not be listening when spoken to.
- Daydream, become easily confused, and move slowly.
- Have difficulty processing information as quickly and accurately as others.
- Struggle to follow instruction.
- Have trouble understanding minute details.

A child with ADHD hyperactive–impulsive type has most or all the following symptoms excluding situations where these symptoms are better explained by another psychiatric or medical condition (American Psychiatric Association, 2013).

- Fidget and squirm in their seats.
- Talk nonstop.

- Dash around, touching or playing with anything and everything in sight.
- Have trouble sitting still during dinner, school, doing homework, and story time.
- Be constantly in motion.
- Have difficulty doing quiet tasks or activities.
- Be very impatient.
- Blur out inappropriate comments, show their emotions without restraint, and act without regard for consequences.
- Have difficulty waiting for things they want or waiting for their turn in games.
- Often interrupt conversations or other's activities.

Problem behaviors can be classified into two conditions: externalizing and internalizing behaviors. Externalizing behaviors can be covert or overt and include conduct disorders and patterns of aggressiveness, while internalizing behaviors consist of anxiety and depression. Children and adults with ADHD can exhibit both externalizing and internalizing behaviors. Typically, internalizing behaviors are seen more in adolescents and adults with ADHD (Raymond, 2017, p. 133).

Providing effective classroom intervention could be challenging for educators of students with ADHD. One of the common treatments of ADHD in children is the use of medication, however, the helpfulness of medication is still on debate among educators. In the study conducted by Moore, Russell, Arnell, and Ford (2017) regarding experiences of teachers of students in managing students with ADHD in the classroom, educators in this study questioned the helpfulness of ADHD medication. The educator-participants utilized some school-based interventions, such as broad strategies, student-centered, and inclusive strategies. They suggested that there's a need for further investigation on the implementation of evidence-based school interventions for ADHD.

Research on ADHD shows that girls tend to have less hyperactivity, inattention, and impulsivity but more intellectual problems (Gershon, 2002). Symptoms of hyperactivity tend to go away with age and turn into "inner restlessness" in teens and adults with ADHD (Kooij et al., 2010). Children with ADHD are known with diverse problems resulting from paying attention which inadvertently leads to poor performance. However, it has been discovered that many children with ADHD have a good attention span for tasks they find interesting. Then, therefore, it implies that any teaching strategy that mediates on inattention and retention of attention will ultimately improve children with ADHD academic performance provided such strategy has inherent or in-built capacity to arouse and sustain their interest.

1.2 Importance of the Study

Research findings suggest that the adoption of learner-centered strategy based on the structure and function of the brain can improve learners' academic performance (Sousa, 2008; Lucas, 2004). Brain-based Education is the purposeful engagement of strategies that are applied on the platform of how our brain works in the context of education. Brain-based learning strategy is a learner-centered and teacher facilitated strategy that utilizes learners' cognitive endowments. Sousa (2004) says a brain-based approach integrates the engagement of emotions, nutrition, enriched environments, music,

movement, meaning making and the absence of threat for maximum learner participation and achievement.

The three instructional learning techniques for brain-based strategies identified by researchers (Sousa, 2004; Ryan & Abbot, 1999; Caine & Caine, 1998; Jensen, 1998) are: (a) Relaxed Alertness: It consists of low threat and high challenge. This technique is used to bring the brain to a state of optimal learning; (b) Orchestrated Immersion: This tries to eliminate fear in learners, while maintaining a highly challenging environment; and (c) Active Processing: this technique allows the learners to consolidate and internalize information by actively processing it.

The brain-based teaching strategy is based on the structure and functions of the brain. According to Lucas (2004) it is normal for learning to occur if the brain is not prohibited from fulfilling its normal processes. Lucas likened brain functionality to that of a powerful processor. Brain-based learning is the result of the understanding of how the brain learns and how it relates into the education field. Brain-based learning informs educators how to organize and create lessons based on how the brain functions organically.

The investigators, therefore, are of the view that if brain-based teaching strategy is adopted to teach mathematics, children with ADHD could be better improved in terms of contextual thinking, creative reasoning, logical thinking, sequential learning, intuitive knowledge and insightful learning—which are resistant to forgetting and these would aid better cognitive and affective learning outcomes in mathematics with attendant features of arousing and sustaining children with ADHD attention in teaching-learning episode.

Anderson (2002) argued that transfer between tasks is a function of the degree to which the tasks share cognitive elements. It is therefore hoped that such learners would be able to display an improved level of achievement irrespective of their anxiety level and emotional disposition. Anxiety is a generalized emotional state. Worries when frequent and intense may lead to anxiety, a “painful uneasiness of mind concerning impending or anticipated ill” (Levine, 1995). Anxiety is characterized by apprehension, uneasiness and foreboding from which the individual cannot escape, it is accompanied by feeling of helplessness because the anxious person feels blocked and unable to find a solution to his problem. Trounce (1985) held that anxiety is a very common symptom and a certain amount is useful to the individual as it acts as stimulant and increases efficiency. “Too much anxiety” Trounce says “have reverse effect and interfere seriously with the patient life”. Umoinyang (1999) pointed out that any form of anxiety is likely to relate positively with failure of students in an academic encounter or relate negatively with academic performance. This position suggests that anxiety is bound to relate or cause academic achievement at the low cognition level. It is argued that students may fail examination not because they are less capable but because anxiety interfered with their mental functioning, hindering recall and thereby leading to poor performance. Students with disabilities often experience a large amount of anxiety when it comes to learning and doing mathematics. Math anxiety can be defined as an “inconceivable dread of mathematics that can interfere with manipulating numbers and solving

mathematical problems within a variety of everyday life and academic situations” (Buckley & Ribordy, 1982, p. 1). This has become a serious obstacle for many students. In order to help prevent or reduce math anxiety, educators need to provide experiences that will help improve students’ dispositions about mathematics (Furner, 2016). They need to provide learning opportunities for students to make positive connections across the various mathematics domains so that they will be engaged in affirming learning experiences. Thus, it becomes relevant and timely to shift ground from stereotype teaching methods, which make high anxiety permissible and less utilization of cognitive endowments in students to learner-centered and teacher-facilitated instructional strategies; one of such strategies is “brain-based” learning strategy, which is an innovative approach to the teaching and learning of mathematics and other school subjects. Therefore, it was in view of this that this work investigated through pretest, posttest, control experimental design, the application of brain-based teaching strategies on the academic performance of children with ADHD in mathematics.

1.3 Statements of the Problem

The problem of this study, therefore, was to investigate through experimental design, the application of Brain-based teaching strategies on children with ADHD learning outcomes in mathematics. The study also took cognizance of mathematics anxiety level on children with ADHD in mathematics and gender as moderator variables.

1.4 Research Questions

The following research questions were raised to guide the study:

Research Questions I: Does the application of Brain-based Teaching Strategies influence the academic performance of children with ADHD?

Research Questions II: Does children’s gender have significant effect on the application of brain-based teaching strategies?

Research Questions III: Does the application of Brain-based Teaching Strategies have significant effect on children with ADHD Mathematics Anxiety level?

1.5 Hypotheses

Three null hypotheses were formulated and tested at 0.05 alpha level of significance.

H₀₁: There is no significant difference between the posttest mean scores of children with ADHD exposed to the application of brain-based teaching strategies and those exposed to the conventional method in mathematics.

H₀₂: There is no significant difference in the academic performance of male and female children with ADHD taught with the application of Brain-based Teaching Strategies and those taught with conventional method in Mathematics.

H₀₃: There is no significant difference in the academic performance of children with ADHD–low mathematics anxiety level and those with high mathematics anxiety level.

2. Method

The design consisted of two treatment groups, Brain-based Teaching Strategies and Conventional group and Moderator variable of Mathematics Anxiety at two levels (low and high) were used in the study. In using this design, two intact classes of participants were randomly assigned to experimental and control groups respectively. Participants in each group were pre-tested on the dependent variables and thereafter exposed to different treatments. The experimental group was exposed to Brain-based Teaching Strategies while the control group was exposed to conventional strategy. The participants in both groups were post tested after the application of treatment.

2.1 Sample and Sampling Technique

Forty-four fifth grade students with ADHD were purposively selected across one school district for the study. They comprised 18 males and 26 females. All students attended a school district in a suburb school district. Also, four research assistants were trained for the implementation of the experiment.

2.2 Research Instruments

The following two instruments were utilized for the study.

- (i) Achievement Test in Mathematics (ATM)
- (ii) Mathematics Anxiety Rating Scale (MARS)

Achievement Test in Mathematics (ATM)

The ATM was designed to test children's intellectual achievement in mathematics. The test consists of ten multiple-choice questions in the three levels of cognitive domain of *remembering*, *understanding* and *thinking*.

Mathematics Anxiety Rating Scale (MARS)

This is an instrument designed to determine the participants' Mathematics Anxiety at two levels (low and high). Mathematics Anxiety was measured through the use of adapted version of MARS which was developed and used by Beasley (2001). The MARS consists of twenty items on five-point rating scale ranging from 1–*not at all* to 5–*very much*. For each of the items, children are expected to indicate how much each of the items frightens him or her.

2.3 Procedure

2.3.1 Pre-Experimental Activities

Training of Research Assistants: The researchers appointed and trained four research assistants, they were trained on the nature and purpose of Brain-based Instructional Materials designed by the researchers viz;

- (i) NKPM-Needful Knowledge Package in Mathematics.
- (ii) SKACM-Students' Knowledge Acquisition card in Mathematics
- (iii) WLT-Weekly Learning Terrain in Mathematics
- (iv) ICSPM-Index Card Study Profile in Mathematics
- (v) SEC "Q & S" -Evaluation card in Mathematics

2.3.2 Pre-Test Administration

The following instruments were administered as pre-test in that order before the commencement of treatment;

- (i) Mathematics Anxiety Rating Scale (MARS)
- (ii) Achievement Test in Mathematics (ATM)

2.3.3 Post-Test Administration

The two instruments administered after the treatment were:

- (i) Mathematics Anxiety Rating Scale (MARS)
- (ii) Achievement Test in Mathematics (ATM)

3. Data Analysis and Result

Data obtained were analyzed using descriptive statistics of mean scores and standard deviations to explain and compare pre-test and posttest mean scores of the experimental and control groups in all the criteria measured. Analysis of covariance was used to test the hypotheses and estimate the impacts of various factors on the dependent variables.

Table 1. Comparing the Pre-Test, Post-Test and main Gain of Experimental Group and Control Group (Children with ADHD)

Group	N	Pre-test	Post-test	Main gain
Experimental group (Brain-based Teaching Strategies)	22	3.31	21.42	18.11
Control group (Conventional method)	21	2.20	16.41	14.21

The data presented in Table I showed that the experimental group had a mean scores value of 3.31 in the pretest and a mean score value of 21.42 in the post-test, making a pretest, posttest mean score gain in experimental group to be 18.11 but the control group had a mean score value of 2.20 in the pretest while a mean score in the post-test is 16.41 with a pretest and posttest main gain of 14.21. With this result, the children in the experimental group performed better in the test conducted than the control group. Hence the application of Brain-based Teaching Strategy is more effective than the conventional method on children with ADHD academic performance.

Table 2. Comparing Pre-Test, Post-Test and Main Mean Score Gain of Male and Female on the Effects of the Application of Brain-Based Teaching Strategy and Conventional Method in Mathematics

Application of Brain-based Teaching Strategy					Conventional Method			
Gender	N	Pre-test	Post-test	Main gain	N	Pre-test	Post-test	Main gain
			t				t	
Male	18	4.66	23.18	18.52	18	3.12	14.23	11.11
Female	26	3.57	20.77	17.20	26	2.42	13.37	10.90

Table 2 showed that male children with ADHD who were taught with the application of Brain-based had a mean score of 4.66 in pretest while the post-test mean score is 23.18 making pretest and posttest mean gain in the male children taught with the application of Brain-based Teaching Strategy to be 18.52. However, Female children with ADHD in the Experimental group had a pretest mean score 3.57 and a posttest mean score of 20.77 with a pretest and posttest mean score gain of 17.20. Again, Male children with ADHD that were taught with the conventional method had a pretest mean score of 3.12 while the posttest mean score is 14.23 with a pretest and posttest mean score gain of 11.11. Meanwhile, female children taught with conventional method had a pretest and posttest mean scores of 2.42 and 13.37 respectively with a pretest and posttest mean score gain of 10.90. These results showed that male children had higher mean score value than female children. Thus, there is an effect attributable to gender and treatment in terms of academic performance of children with ADHD.

Table 3. Comparing Pre-Test, Post-Test and Main Mean Score Gain of Mathematics Anxiety (Two Levels: Low and High)

Mathematics Anxiety	N	Pre-test	Post test	Main Gain
Low	19	3.29	21.52	18.23
High	25	2.86	19.41	16.55

The data presented in Table 3 showed that the experimental group with low mathematics anxiety level had mean score values in the pretest and posttest of 3.29 and 21.52 respectively with a main gain mean score of 18.23. However, the control group had mean score values in the pretest and posttest of 2.86 and 19.41 respectively with a main gain mean score of 16.55. Table 3 showed that children with high Mathematics Anxiety obtained a lower mean score, while children with low mathematics anxiety group had a higher mean score. It could be inferred that children with low Mathematics Anxiety benefit more from the treatment while the probability of improving the performance of children who are in the category of high anxiety level is ascertained.

Table 4. Comparing the Significant Difference of Standard Deviation of Brain-Based Teaching Strategy and Conventional Method

Group	N	X	S. D	df	t-cal	t-tab	Decision
Brain-based Teaching Strategy	44	2.53	0.73				
Conventional Method	44	2.51	0.71	88	2.20	1.960	Significant

Table 4 showed that the mean score value of children with ADHD taught with Brain-based Teaching Strategy is higher than those taught with conventional method indicating that those taught with the application of Brain-based Teaching Strategy performed higher than those taught with conventional method. Since t-cal value (2.20) > t-tab value (1.96) at alpha level of 0.05 and degree of freedom of 88, the null hypothesis one is rejected.

Table 5. Comparing the Significant Difference of Mean Groups of Male and Female

Group	N	X	S. D	df	t-cal	t-tab	Decision
Male	18	2.51	0.87				Not
Female	26	2.53	0.85	44	2.20	1.96	Significant

Table 5 showed that the mean values of male and female have no significant difference because the range values were very close. By implication, the stated Null hypothesis two is accepted.

Table 6. Comparing the Significant Difference of Academic Performance of Low and High Mathematics Anxiety Level of the Participants

Anxiety Level	N	X	S. D	df	t-cal	t-tab	Decision
Low	21	4.75	0.93				
High	23	2.13	0.81	44	3.62	1.96	Significant

Table 6 showed that the mean rating of low Mathematics anxiety level is higher than those with high Mathematics Anxiety level. Therefore, the null hypothesis three is rejected which indicated that there is a significant difference in the academic performance of low Mathematics anxiety level and high Mathematics Anxiety level.

4. Discussion

Based on the findings of this study, the effectiveness of Brain-based Teaching Strategy in achieving optimal knowledge and high academic performance among children with ADHD has been established. This study has also shown the inherent weakness of the conventional method as a means of enhancing learning in mathematics. The effectiveness of the application of Brain-based Teaching Strategy in this

study lies in the fact that, it is based on the principles of relaxed alertness, orchestrated immersion and active processing which create supportive learning environment for all categories of learners.

4.1 Recommendations

Based on the findings, the following recommendations are made: To improve children with ADHD achievement in mathematics, innovative strategy such as Brain-based Teaching Strategy should be adopted for regular classes and children with learning disabilities. In the use of this strategy, teachers should not only create learning environments that fully immerse children in an educational experience but also eliminate fear in children while maintaining a highly challenging environment with emphasis on consolidation and internalization of information in them.

4.2 Limitation of the Study

The researchers caution the generalization of the results because the study was done in one suburban school district. The findings from a similar study may not be the same. Also, since all participants were from similar social economic status results may have been affected therefore, it is unknown if children from higher or lower socio economics status would perform similarly. A more accurate research may be conducted if students were administered with the assessment multiple times over a longer period.

5. Conclusion

This study has found that the application of Brain-based Teaching Strategy improved children with ADHD achievements in mathematics. Treatment is also anxiety sensitive with respect to their disposition towards mathematics.

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