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Impact of Brain-Based Instructional Strategy on Academic Performance of Deaf Students in Mathematics in Oyo School of Handicapped, Nigeria

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Abstract

This study investigated the impact of brain-based instructional strategy on academic performance of students who are deaf or hard of hearing (D/HH) in mathematics. A pre-test, post-test, control group quasi-experimental design was adopted with a 2 x 3 x 2 factorial matrix. The sample size of 41 students who are D/HH were randomly selected in the school. Two intact classes each were randomly assigned to the experimental group (Brain-Based Instructional Strategy-BBIS) and the Control Group respectively. The instruments used were, Mathematics Attitude Questionnaire (r = 0.81), Cognitive Style Test (r = 0.80), and Mathematics Anxiety Rating Scale (r = 0.81). Three research questions guided the study. Data obtained were analyzed using descriptive statistics of mean scores and standard deviations to explain and compare pretest and posttest scores of the experimental and control groups in all the criteria measured. Brain-based instructional strategy was more effective at improving students' attitude to mathematics than the conventional method. The findings of the study also indicated that tension and test-phobia which normally permeates the teaching-learning process of mathematics was highly reduced due to the optimal use of diverse brain compatible instructional materials among students who are D/HH.

Keywords

brain-based, deaf, Hard of Hearing, attitude

1. Introduction

Hearing is what keeps us in touch with our world. It plays a significant role in expressing and receiving language. Hearing loss creates problems in how an individual expresses and receives languages in turn causing social, communication, and educational challenges (Hall, Oyer, & Haas, 2001). Educators therefore need to seriously devise suitable strategies that could optimally enhance effective learning among students who are D/HH. The term *deaf* is used to refer to a person whose sense of hearing is impaired to the extent that linguistic formation processing is negatively affected, with or without the use of amplification. This condition adversely affects the educational performance of such an individual. The term *Hard of Hearing* is used to refer to a person whose sense of hearing is impaired, the condition may be permanent or fluctuating and also adversely affects a person's educational performance (Moore, 2001).

The educational achievement, social development, and vocational success of an individual with a hearing loss is influenced by many factors including the type and degree of hearing loss, the attitudes of the child's parents, the siblings and the affected child, the opportunities available for the child to acquire a first language, and the presence or absence of other abilities (Marschark & Wauters, 2008). Research evidence shows that students who are D/HH perform significantly low in school subjects (Moores, 2001). Empirical reports on techniques which could assist students who are D/HH to perform effectively in the face of these constraints are hard to come by (Schlogs, Smith, & Stoker, 1986; in Aderibigbe, 2014).

Educators of the deaf need to be sensitive to the social, academic, and emotional challenges a child who is D/HH has in any given day. Extra energy is required in interpreting information through lip-reading and sign language interpreting that would otherwise be simply heard by children without a hearing loss. Students who are D/HH and/or linguistically diverse had to work extra hard to be successful in academics (Ayantoye & Luckner, 2016). There are extra steps in processing audio information that students who are D/HH need to take in order to fully comprehend. Teachers need to be sensitive to the reality that there is usually more than one visual thing happening at one time. For an example, a teacher talking (and the interpreter in sign language) while expecting students to take notes of the lecture. Expecting a students who are D/HH to read lips, read the signing, and take notes at the same time is not realistic. The main notes could be provided to that student beforehand so that the student can focus on lip reading and interpreting manual signs of the lecture.

Hall, Oyer and Haas (2001) suggested that teachers support students who are D/HH by frequently checking to ensure the mastery of information provided in class. They provided an alternative suggestion in assigning a hearing peer to assist the child who is D/HH to be an active participant in school activities for those times the teacher is preoccupied with other students. Another suggestion was for the teacher to "learn to read" the child's facial expressions, this enables the teacher to receive feedback regarding the student's understanding of the material presented. This particular suggestion does not just happen overnight, it is a process that develops overtime as the teacher becomes familiar with the student. In cases when the student doesn't understand what was said, rephrasing with additional words relevant to what you want to say can provide cues to aid speech comprehension, especially in classroom settings where sign language interpreting is not always made available. When rephrasing, use words central to the main idea of the communication. For example, if you are saying, "You can get your coat from your locker now", and the student doesn't understand, you could say, "Everyone is getting ready for the bus; you can get your coat from your locker now" (Kaveravek, 2002, p. 16).

Research evidence shows that students who are D/HH face many challenges in our audio saturated educational settings. According to Moores (2001), there is no doubt that educators of the deaf will continue to address sociocultural and communication factors as well as academic achievement but it is imperative that they are cognizant of the dominant emphasis on achievement in basic subjects such as, math, science, English, and social studies. In the art of teaching-learning process, there are myriad of attendant constraints that hinder students who are D/HH from optimal academic performance particularly in mathematics and science. The importance of sound knowledge of mathematics to individuals in our daily activities is obvious. Studies affirm that one cannot do without the use of fundamental principles of mathematics in daily life. Mathematics has an inbuilt potentials of the following significant values (which has made it a most welcome part of education); practical or utilitarian value, disciplinary value, and cultural value.

Awofola (2004), quoting Chalfant and Scheffehn (1969) remarked that mathematics is the abstract science of space and number, which deals with space configuration and the interrelationships and abstraction of numbers. He also noted that mathematical education in Nigerian schools was derived from the British National Curriculum (2000) as stated below:

Mathematics equips students' uniquely powerful tools to understand and change the world. These tools include logical reasoning, problem-solving skills and the ability to think in abstract ways. Mathematics is useful, in everyday life, many forms of employment, science and technology, medicine, the economy, the environment, development and in public-decision making (p. 17).

Onabanjo (2004) noted that in every branch of industry, mathematics has come to play an imperative role as a result of its wide spread application in all areas of science and technology and the economy.

Several instructional strategies have been recommended for the teaching-learning process of mathematics, which include the use of personalized system of instruction (Kadiri, 2004; Ku & Sullivan, 2000); Clubs and Games (Afuwape, 2002; Aremu, 2001) combined strategy of concept mapping and problem solving (Awofala, 2000); self-regulatory and cooperative learning strategies (Ifamuyiwa, 2005) and computer and test assisted programmed instruction (Etukudo, 2002).

While it is evident that these strategies are learners-centered (Ifamuyiwa, 2005; Afuwape, 2002) and are in favor of conceptual, sequential and logical aspects of mathematics, none of them takes into consideration the function and structure of the brain. This is a gap which this study attempted to fill especially among students who are D/HH. Research evidence suggests the adoption of learner-centered strategy based on the structure and function of brain can improve learners' academic performance. (Sousa, 2008; Adebayo, 2005; Lucas, 2004; Wilson, 2015).

Brain-based learning strategy is a learner-centered and teacher-facilitated strategy that utilizes learners' cognitive endowments. Sousa (2004) stated that 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.

Proponents of brain-based instructional strategy (Sousa, 2004; Ryan & Abbot, 1999; Caine & Caine, 1998; Jensen, 1998) identified three instructional learning techniques of the strategy. These are:

(i) Relaxed Alertness: It consists of low threat and high challenge. It is the technique employed to bring the brain to a state of optimal learning.

(ii) Orchestrated Immersion: This is a technique of trying to eliminate fear in learners, while maintaining a highly challenging environment.

(iii) Active Processing: This technique allows the learners to consolidate and internalize information by actively processing it.

Brain-Based learning strategy! What is all about? To many, the term "brain-based" learning sounds redundant isn't all teaching and learning brain-based? Advocates of brain-based teaching insist that there is a difference between "brain-compatible" education and "brain-antagonistic" teaching practices and methods, which actually impair learning.

Brain-based learning sometimes called Brain-compatible is an educational approach based on what current research in neuroscience suggests about how our brains naturally learn best (Lucas, 2004). The learning strategy derived from this research can easily be integrated into any learning environment, from the kindergarten classroom to a seminar for adult.

With new technologies that allow scientists to observe the brain functions as they occur, we are gaining insights into how the brain learns, assimilates, thinks and remembers. From these findings, an approach to education called the brain-based learning has evolved.

This instructional strategy is based on the structure and functions of brain. Lucas (2004) asserts that as long as the brain is not prohibited from fulfilling its normal processes, learning will occur since everyone is born with a brain that functions as an immensely powerful processor. Understanding how the brain learns and relating it to the educational field resulted in the concept known as brain-based learning. It is defined as any teaching strategy that utilizes information about the human brain to organize how lessons are constructed and facilitated with emphasis placed on how the brain learns naturally.

Student beliefs and attitudes have the potential to either facilitate or inhibit learning Gibborns, Kimmel and O'Shea (1997) opined that students' attitudes about the value of learning science may be considered as both an input and outcome variable because their attitudes towards the subject can be related to educational achievement in ways that reinforce higher or lower performance. This means that those students who do well in a subject generally have more positive attitudes towards that subject and those who have more positive attitudes towards a subject tend to perform better in that subject.

Studies have shown that test anxiety is associated with a significant performance decrement in students (Zakaria & Nordin, 2008). They stated that the principal cause of mathematics anxiety lies in the teaching methodologies used to convey basic mathematical skills. To him, teachers create anxiety by placing too much emphasis on memorizing formulae, learning mathematics through drill and practice, applying rote-memorized rules and setting out work in the traditional way.

Statement of the Problem

The Problem of this study was to investigate through quasi-experimental design, the impact of brain-based instructional strategy on academic performance of the students who are D/HH in mathematics in Oyo School of Handicapped in Oyo State, Nigeria.

Research Question I:

What is the pre-test and post-test mean scores of achievement in and attitude to Mathematics score of students who are D/HH exposed to Brain-Based Learning and Conventional Strategies?

Research Question II:

What is the pre-test and post-test mean score of achievement in and attitude to mathematics scores of (i) Low (ii) Medium, and (iii) high mathematics anxiety group?

Research Question III: What is the mean score of achievement in and attitude in Mathematics scores of Analytic and Non-Analytic Cognitive Style Groups?

Importance of the study

The brain-based instructional strategy encourages peer teaching and elaborate rehearsal among the students and studies have shown that students will remember content more if it is moved from short-term memory to long-term memory for the actualization of optimal learning for "neurons that wire together fire together" (Sousa, 2006) people learn best when they are teaching the materials they are learning; the more a particular sequence of neuron is used, the stronger it becomes.

The provision of enriched learning environment, well-designed bran-compatible instructional materials and judicious use of varied strategies in a learning episode as was used in the study had put to minimal the fear and undesirable attitude in Mathematics among the deaf students.

One of the merit of brain-based learning strategy on student achievement in mathematics is associated with opportunity for relax alertness created in the study. Relax alertness entails eliminating fears in learner, while maintaining a highly challenging learning environment. In this study, the teacher created a relax alertness learning environment by engaging the learner in "brain gym" exercises. These include "drink water", "brain buttons, etc.". It is evident that learning can be hindered due to dehydration (Sousa, 2006). The rate of perspiration increases when one is under stress and this lead to dehydration which affect concentration negatively (Sousa, 2006). In this study learners were encouraged to drink minimal quantity of water before and during class.

2. Method

The design consisted of two treatment groups (Brain-Based Instructional Strategy and Conventional Instructional Strategy), Moderator Variables of Mathematics Anxiety at three levels (low, medium and high) and Cognitive Style at two levels (analytic and non-analytic).

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 Instructional Strategy 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 Techniques

Forty one students who are deaf or hard of hearing participated in the study. The sample size of the study was 41 students, and the ratio of male to female is 7:5. The means of communication in the school is Total Communication, which encompasses the use of sign language, finger movements, lip-reading, finger spelling, and picture reading. A minimum of two teachers who are fluent in sign language were in charge of a class of seven students.

Purposive random sampling technique was used to select the school of study while sample random technique was used to select the forty one participants for the study. Two intact classes were utilized, each were randomly assigned to the experimental and control groups respectively.

2.2 Research Instruments

The following three instruments were used for data collection and they are:

(i) Mathematics Attitude Questionnaire (MAQ)

(ii) Cognitive Style Test (CST)

(iii) Mathematics Anxiety Rating Scale (MARS)

2.2.1 Mathematics Attitude Questionnaire (MAQ)

This is an instrument of twenty items that elicits information from the participants on their attitude towards mathematics. The instrument is made up of two sections: A and B. Section A is designed to elicit responses in relation to pupil's name, age, gender, class and name of school. Section B is made up of twenty items (ten positive and ten negative statements), requesting participants to indicate their attitude towards the study of Mathematics based on the four-point Likert scale. Each participant was requested to tick an appropriate option weighted as follows:

Strongly Agreed (SA)	-	4
Agreed (A)	-	3
Disagreed (D)	-	2
Strongly Disagreed (SD)	-	1

This rating was meant to reflect how the participants felt about the particular statement.

2.2.2 Cognitive Style Test (CST)

This is a reasoning test used to measure how students choose and analyze set of pictures of common objects, animals, plants or artifacts for the purpose of classifying them. The language he or she uses in categorizing these phenomena presumably reflects each of individual's style of categorization. The Cognitive Style Test (CST) is a modified version of the Cognitive Style Test developed by Sigel (1967).

The modification and validation were done by Onyejiaku (1980) to reflect Nigerian environment as cited by Afuwape (2002).

The CST consists of twenty cards numbered 1 to 20. Each card contains three pictures in black and white, two of which could have one thing or the other in common or could go together in some ways. The CST was used to classify the students into "analytic" and "non-analytic" styles on the basis of their statements regarding the way they perceived the pictures. The students were asked to respond to each set of three pictures by noting how any two of the three pictures in the set go together or are related in any way. The statements made by the students regarding way they perceived the pictures and classified any two together could be categorized into three thus:

Analytic Descriptive (AD),

Categorical Inferential (CI) and,

Relational Contextual (RC).

Analytic Descriptive Response: Students here place together objects based on their shared or common characteristics, which are directly discernible. Example, in a card containing a man, a bed and a chair, participants could place together bed and chair because "they are made of wood".

Categorical Inferential Responses: Participants here, place together objects on the basis of super ordinate features, which are not directly discernible (abstract), but are inferred. Example, participants here will place a bed and chair together because "they are for relaxation".

Relational Contextual Responses: Participants could, place together objects or events on the basis of features establishing a relational link between them. The two stimuli or objects here are independent conception ally, rather each drives meaning from the other. Hence, this style is sometimes called global or holistic or contextual mode of categorization. Example, participants here will place together "the man and the bed" or "the man and the chair" on the ground that, "the man can sit on the chair" or "sleep on the bed".

In this study, analytic style participants were those who scored above the median on Analytic Descriptive and Categorical Inferential responses and below and median on Relational Contextual responses. Non-analytic style participants were those who scored above the median on Relational Contextual responses and below the median on Analytic Descriptive and Categorical Inferential response.

2.2.3 Mathematics Anxiety Rating Scale (MARS)

This is an instrument designed to determine the participants' mathematics anxiety at three levels (low, medium or high). Mathematics anxiety was measured through the use of an adapted version of Mathematics Anxiety Rating Scale (MARS) developed and used by Beasley (2001). The MARS has two sections, A and B. Section A is designed to elicit responses in relation to participants' age, gender and name of school. Section B consists of twenty items based on five-point scale ranging from 1 = not at all to 5 = very much. For each of the items, students are expected to indicate how much each of the items frightens him/her.

2.3 Procedure

2.3.1 Pre-Experimental Activities

Training of Research Assistants: The researcher appointed and trained four research assistants; they were trained on the nature and purpose of the Brain-based instructional Materials. The research Assistants were well versed in sign Language as sign communication was the major means of communication being used in class interaction. Essentially, the research assistants were needed in the area of administration of pre-test and post-test, organization and arrangement of research materials.

2.3.2 Pre-Test Administration

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

(i) Cognitive Style Test (CST)

(ii) Mathematics Anxiety Rating Scale (MARS)

(iii) Mathematics Attitude Questionnaire (MAQ)

3. Data Analysis and Result

Data obtained were analyzed using descriptive statistics of mean scores and standard deviations to explain and compare pre-test scores of the experimental and control groups in all the criteria measured.

Research Question 1: What is the pre-test and post-test mean score attitude to Mathematics scores of students exposed to Brain-Based Learning and Conventional Strategies?

Table 1. Achievement and Attitude Mean Scores of Students Exposed to Brain-Based Learning and Conventional Strategies

Treatment		Achievement			Attitude	
		N	$\bar{x}$	SD	$\bar{x}$	SD
Experimental	Pre-test	41	12.43	1.86	12.41	1.87
	Post-test	41	15.83	3.71	14.73	3.73
Control	Pre-test	41	12.47	1.74	12.43	1.71
	Post-test	41	13.40	2.72	13.51	2.75

Table 1 showed that the pre-test and post-test achievement mean scores of students in the experimental group were 12.43 and 15.83 with corresponding standard deviations of 1.86 and 3.71 while that of the control group were 12.47 and 13.40 with corresponding standard deviations of 1.74 and 2.72 respectively. The result revealed that there was an improvement in the post-test mean scores of the students in the experimental group. This indicated that students in the experimental group have acquired much Mathematics achievement as reflected in their post mean scores. Thus, the Brain-Based Learning Strategy actually has influence on pupil's academic achievement in Mathematics.

The Table further showed that the pre-test and post-test Mathematics attitude scores of students in the experimental group were 12.4 and 14.73 with corresponding standard deviations of 1.81 and 3.73 while that of the control group were 12.43 and 13.51 with corresponding standard deviations of 1.71 and 2.75 respectively. The results revealed that there was an improvement in the post-test mean scores of the students in the experimental group. This indicated that treatment actually has influence on students' attitudes to Mathematics in the experimental group.

Research Question 2: What is the pre-test and post-test mean score of achievement in and attitude to Mathematics scores of (i) low, (ii) medium, and (iii) high mathematics anxiety groups?

Table 2. Achievement and Attitude Mean Scores of Low, Medium and High Mathematics Anxiety Groups

Mathematics Anxiety Group		Achievement			Attitude	
		N	$\bar{x}$	SD	$\bar{x}$	SD
Low	Pre-test	41	11.43	1.84	12.14	1.81
	Post-test	41	13.41	3.71	13.41	2.76
Medium	Pre-test	41	12.42	1.16	12.42	1.86
	Post-test	41	13.19	2.71	13.56	2.75
High	Pre-test	41	12.42	1.87	12.14	1.82
	Post-test	41	13.41	2.72	13.41	3.61

Table 2 showed that the pre-test and post-test achievement mean scores of students in low, medium and high Mathematics anxiety groups were 11.43 and 13.41; 12.42 and 13.19 and 12.42 and 13.41 respectively. Their standard deviations were 1.84 and 3.7; 1.16 and 2.71, 1.87 and 2.72 respectively. The result revealed that students with low mathematics anxiety recorded the highest achievement mean scores in mathematics. These results concurred with the findings of Tapia (2004), who reported that students having little or no mathematics anxiety scored significantly higher in mathematics than students with some or high mathematics anxiety, and students with some mathematics anxiety scored significantly higher than students with high mathematics anxiety.

The table further showed that the pre-test and post-test Mathematics attitude mean scores of students in low, medium and high mathematics anxiety groups were 12.14 and 13.41, 12.42 and 13.56 and 12.14 and 13.41 respectively. The result indicated that students with low mathematics anxiety recorded the highest attitude scores, followed by the medium mathematics anxiety group obtained the lowest attitude scores in Mathematics. These findings corroborated the findings of Zakaria and Nordin (2007) that students with high mathematics anxiety scored significantly lower in achievement. Numerous authors have suggested that higher achiever students are more apt to be less anxious (Hembree, 1990). The Brain-Based Learning Strategy was more effective in promoting the attitude of the low and medium mathematics anxiety groups while the attitude of the high mathematics anxiety groups was best improved through the conventional method.

Research Question 3: What is the mean score of achievement in and attitude in Mathematics scores of Analytic and Non-Analytic Cognitive Style Groups?

Table 3. Achievement and Attitude Mean Scores of Students in Analytic and Non-Analytic Cognitive Style Groups

Cognitive Style Group		Achievement			Attitude	
		N	$\bar{x}$	SD	$\bar{x}$	SD
Analytic	Pre-test	41	11.44	1.84	12.14	1.88
	Post-test	41	13.56	3.76	13.46	2.76
Non-Analytic	Pre-test	41	12.41	1.41	12.42	1.81
	Post-test	41	13.61	2.73	13.56	3.72

Table 3 showed that the pre-test and post-test achievement mean scores of students in the analytic were 11.44 and 13.56 with standard deviation of 1.84 and 3.76 while that of the non-analytic group were 12.41 and 13.61 with standard deviation of 1.41 and 2.73 respectively. This indicated that analytic group had better achievement mean scores than the non-analytic group. The table further showed that the pre-test and post-test Mathematics attitude mean scores of analytic cognitive style students were 12.14 and 13.46 with standard deviations of 1.88 and 2.76 while that of non-analytic cognitive style students were 12.42 and 13.56 with standard deviations of 1.81 and 3.72 respectively. This indicated that there was not much difference in their attitudinal disposition to Mathematics. However, considering the treatment and cognitive style, the Brain-Based Learning Strategy was more effective than the conventional method in enhancing the achievement of both the analytic and non-analytic cognitive style students who are D/HH.

4. Discussion

The Brain-based learning group obtained higher mathematics attitude mean scores than the Control group. The difference in mathematics attitude mean scores between the Brain-based learning group and the control group was however not significant. The investigators therefore are of the view that if brain-based instructional strategy is adopted to teach Mathematics, learners 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 affective learning outcomes in Mathematics among students who are D/HH.

Thus, it becomes imperative, relevant and timely to shift ground from stereotyped teaching methods, which make high anxiety permissible and less utilization of attitudinal pull.

One of such strategies is "brain-based" learning strategy, which is an innovative approach to the teaching, and learning of Mathematics. The result confirms the assertion of researchers (Adebayo, 2005) that students who were exposed to brain-based instructional strategy in Chemistry performed significantly higher in their attitude mean scores than their counterparts who were exposed to the conventional method.

Recommendations

Based on the findings of this study, the following recommendations are made;

To improve students who are D/HH attitude in Mathematics, innovative strategy such as Brain-Based Instructional Strategy should be adopted in secondary schools.

Teachers of Mathematics should endeavor to take cognizance of "prime times" during any teaching-learning process. For instance, in a 40-minute period, students' attention is strongest for the first 20 minutes, then the brain needs "down times" for approximately 10 minutes (Brains downshifting is like a camera that has a reduced focus). The next ten minutes is the next best teaching time.

Teachers of Mathematics should be encouraged to make adequate provision of an enriched learning environment, well-designed brain-compatible instructional materials and judicious use of varied strategies in a learning episode. This would put to minimal, the alarming rate of fear, test phobia and undesirable attitude of students who are D/HH towards Mathematics and others school subjects.

Limitation of the study

Studies that will spread over a longer period can be conducted. Experiment of this nature requires prolonged time for the training of the participants and research assistants and for the implementation stage. Students were labeled as deaf or hard of hearing, it is uncertain the level of the hearing loss, however, the setting being in Africa the students who typically attend school for the handicap have little to no residual hearing therefore, all of them are in the category of severe to profound deafness. Other intervening variables apart from cognitive styles and Mathematics Anxiety Rating Scale can be built into further researches. By implication this will enable other researchers to systematize the outcomes of mathematics and other subjects instruction to produce better results thereby improving performances of learners.

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