IMPACT OF BRAIN-BASED INSTRUCTIONAL STRATEGY AND MATHEMATICS ANXIETY ON STUDENTS' ATTITUDE TO SENIOR SECONDARY SCHOOL MATHEMATICS.

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Abstract

This study investigated the impact of brain-based instructional strategy and mathematics anxiety on students' attitude to Senior Secondary School 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 was 522 Senior Secondary School II Students from nine randomly selected schools in Oyo State, Nigeria. Five schools were randomly assigned to the experimental group (Brain-Based Instructional Strategy – BBIS), while four schools were assigned to the control group (Non-Brain-Based Instructional Strategy – NBBIS). The instruments were: Mathematics Attitude Questionnaire (r = 0.83), Cognitive Style Test (r = 0.81), Mathematics Anxiety Rating Scale (r = 0.81). One research question and one hypothesis guided the study. Data obtained from the research question were analyzed using mean scores and standard deviation. The hypothesis was tested at 0.05 level of significance using the Analysis of Covariance (ANCOVA).

Brain-based instructional strategy was more effective at improving students' attitude towards Mathematics than the conventional method. Teachers of Mathematics could, therefore, adopt this strategy for teaching secondary school students. This would go a long way in reducing fear, test-phobia and undesirable attitude in Mathematics among students. It would also boost the interest of the Mathematics teachers in teaching the subject without stress.

INTRODUCTION

The list of remarkable achievements in the realm of Mathematics as a subject in Nigeria cannot be exhausted without mentioning the various attempts put forward in ensuring effective Mathematics teaching and learning. The Mathematics teachers' success in carrying out classroom instruction is a function of their creative personality, sustained by a spirit of dynamic investigation, innovativeness and exploration to bring into harmony, the triadic relationships between students, teacher and the subject.

In Nigeria, evidence abounds from past studies that secondary school students often dread and show negative attitude to Mathematics (Ojo, 2003; Popoola, 2002; Akinsola, 2000). This is often the bane of mass failure of students in the subject (Onabanjo, 2004; Popoola, 2002; Chief Examiner's Reports WAEC, 2000-2003).

Table 1: Data on Students' Performance in May/June SSCE Mathematics from 1996 to 2006.

Year	No. of Cand.	Total A1-C6 No %	Total D7-E8	Total A1-E8 No %	Total F9 No %
1996	514342	51587 (10.0)	190839 (37.1)	242486 (47.1)	272466 (52.9)
1997	616923	47252 (7.66)	161526 (26.18)	208778 (33.84)	408145 (66.16)
1998	635686	61208 (9.63)	159000 (25.01)	220208 (34.64)	415478 (65.36)
1999	756680	138098 (18.25)	212514 (28.09)	350612 (46.34)	106068 (53.66)
2000	530074	73816 (32.79)	164819 (31.09)	338635 (63.88)	191439 (36.12)
2001	1023102	83955 (36.55)	334902 (32.73)	718857 (69.28)	304245 (30.72)
2002	908235	09409 (34.06)	334907 (32.62)	644316 (66.68)	263919 (27.98)
2003	926212	41928 (36.91)	331348	673276 (72.02)	252936

			(35.11)		(27.98)
2004	832689	ɜ7484 (34.52)	245071 (28.22)	532555 (62.74)	ɜ00134 (37.26)
2005	1,05485 3	·02982 (38.20)	267600 (25.36)	670582 (63.56)	384271 (36.44)
2006	1181515	ı82123(41.73)	366801 (31.55)	848924(73.28)	332591 (26.72)

Source: WAEC, Research Section, Ibadan.

Table 1 gives a clear picture of the poor and fluctuating performance of secondary school students in WASSCE examinations in Mathematics. This poor performance has been ascribed to lack of preparedness on the part of the candidates (Chief Examiner's Reports, WAEC, 2000-2003).

In a report presented at WAEC monthly seminar by the acting Head of Research Division (2007), it was revealed that students recorded fluctuating performance in Mathematics within the past five years. The recently released WASSCE 2007 results showed that 325,754 candidates representing 25.54% out of 1,275,330 candidates passed at credit levels in Mathematics and four other subjects (Punch, 2007). For example, a breakdown of the statistics on the failure rate and 908,235 candidates, 34.06% representing 309,409 students scored credit and above while 33,4907 (32.62%) students got pass while 33.32% representing 263,919 candidates failed the subject.

In 2003, out of 962,212 candidates that wrote the examination, only 341,928 (36.91%) recorded credit and above while 35.11% representing 331,348 students scored pass and 252,936 candidates representing 27.98% failed. For 2004, out of 832,689 candidates that sat for the school certificate examination in Mathematics, 287,484 (34.52%) scored credit and above while 245,071 students representing 28.22% recorded pass and 37.26% representing 300,134 students failed the subject. In 2005, out of 1,054,853 candidates, only 402,982 students representing 38.20% got credit and above while 267,600 (25.36%) students scored pass and 384,271 (36.44%) failed the subject.

In 2006, out of 1,181,515 candidates that sat for the examination, only 482,123 students representing 41.73% got credit and above while 366,801 (31.55%) students scored pass and 332,591(26.72%) failed the subject. Explanations for this lacklustre performance abound. Some say that learning Mathematics is difficult because it is so abstract and requires more logical and ordered thinking.

Others say that the various symbols used in mathematics make it similar to tackling a foreign language. Education critics maintain that only a few students are really developmentally incapable of handling Mathematics and that the poor performance stems mainly from inadequate supply of quality instructors. According to the report, students' poor performance in WASSCE calls for concern of stakeholders. This apparently has made Mathematics educators to pay more attention towards improving the process of teaching and learning of Mathematics in schools. These include the use of personalized system of instruction (Kadiri 2004; Ku and Sullivan, 2000); clubs and games (Afuwape, 2001; Aremu, 2002); combined strategies of concept mapping and problem solving (Awofala, 2000); Self-regulatory and cooperative learning strategies (Ifamuyiwa, 2005; Ojo, 2003); and computer and text-assisted programmed instruction (Etukudo, 2002; Udousoro, 2000). While it is evident that these strategies are learner-centered (Akinsola and Awofala, 2009; Ifamuyiwa, 2005; Afuwape 2002) and are in favour of conceptual, sequential and logical aspects of mathematics, none of them takes into consideration the function and structure of the brain.

Research evidence suggests that the adoption of learner-centred strategy based on the structure and function of the brain can improve learners' academic performance (Sousa, 2008; Adebayo, 2005; Lucas, 2004; Lacknewy, 2002).

Hart (1983) argued that teaching without an awareness of how the brain works is like designing a glove with no sense of what a hand looks like, for instance the shape of the hand and how it moves. He pushed this analogy even further in order to drive home his primary point; if classrooms are to be places of learning, then "the organ of learning" the brain must be understood and accommodated.

> *All around us are hard compatible tools and machines and keyboards, designed to fit the hand. We are not apt to think of them in that light because it does not occur to us that anyone would bring out some device to be used by human hands without being sure that the nature of hands is considered. A keyboard machine or musical instrument that called for eight fingers on each hand would draw instant*

> *ridicule. Yet we force millions of children into schools that have never seriously studied the nature and shape of the human brain (Hart, 1983, p. 33).*

Brain-based learning strategy is a learner-centred 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.

Proponents of brain-based instructional strategy (Sousa, 2004; Ryan and Abbot, 1999; Caine and 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 it 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 can 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 a 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 the 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.

Mathematics anxiety can be described as a combination of factors as described by (Mitchell, 1987) who stated that Mathematics anxiety is a combination of physical, cognitive and psychobehavioural components. Physical aspects of Mathematics anxiety are biological, consisting of hormonal, chemical and muscular changes in the body, which results in a disability to think (Mitchell, 1987). A number of different factors have been described as the causes of Mathematics anxiety. Norwood (1994) described Mathematics anxiety as the results of different factors including the inability to handle frustration, excessive school absences, poor self-concept, parental and teacher attitudes towards Mathematics and emphasis on learning Mathematics through drill without understanding. A lack of confidence when working in mathematical situations is described by (Stuart, 2000) as the cause of Mathematics anxiety. Hodges (1983) argued that failure or success in Mathematics may be related to individual learning styles and more specifically with the coupling of learning styles and the way in which material is presented. The present study, therefore, investigated through quasi-experimental design, the impact of brain-based instructional strategy and mathematics anxiety on students' attitude to Senior Secondary School Mathematics in Oyo State, Nigeria.

Research Question:

What is the pretest and post-test mean scores of students' attitude towards Mathematics scores of (i) low, (ii) medium, and (iii) high mathematics anxiety groups

Research Hypothesis:

Ho_1: There is no significant main impact of Mathematics anxiety on students' attitude towards Mathematics.

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 groups of participants were randomly assigned to experimental group and control group. Two intact groups were involved in the study, viz: experimental group and control group. Participants in each group were pre-tested on the dependent variables and thereafter exposed to different treatments.

The experimental group was exposed to the Brain-Based Instructional Strategy while the control group was exposed to the Conventional Method. The participants in both groups were post-tested after the application of treatments.

Sample and Sampling Procedure

Five hundred and twenty-two senior secondary students were involved in this study. Stratified random sampling procedure was used in selecting nine schools: five schools from urban and four from rural areas of the three zones (that make up Oyo North Senatorial District) were randomly selected for the study. Five of the schools were randomly assigned to experimental groups and four to control groups.

In each of the nine sampled schools, only two intact classes (SS II) were involved in the study.

Instruments

The following three instruments were used for data collection:

(i) Mathematics Attitude Questionnaire (MAQ)
(ii) Cognitive Style Test (CST)
(iii) Mathematics Anxiety Rating Scale (MARS).

Mathematics Attitude Questionnaire (MAQ)

This is an instrument of twenty items that elicit 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 student'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 a 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.

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 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 perceive 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 the way they perceived the pictures and classified any two together could be categorized into three thus:

- Analytic Descriptive (AD)
- Categorical Inferential (CI)

- Relational Contextual (RC).

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

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

Relational Contextual Responses
Participants here place together objects or events on the basis of features establishing a relational link between them. The two stimuli or objects here are independent conceptionally, rather each derives meaning from the other. Hence, this style is sometimes called global or holistic or contextual mode of categorization. For 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 the 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 responses.

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) and Hopko (2003). 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

Not at all ← 1 2 3 4 5 → Very much

twenty items based on five-point scale ranging from 1 = "not at all" to 5 = "very much". For each of the items, student is expected to indicate how much each of the items frightens him/her.

Table 2: Table of Specification for MARS

S/n	Item Category	Number of Items
1.	***Cringing in terror about Mathematics***	2 (1, 2)
2.	Uneasiness in Mathematics class	1 (3)
3.	Reservation for Mathematics concepts	4(4,5,18,19)
4.	Asking questions in Mathematics class	1(9)
5.	Response in Mathematics class	2(7,8)
6.	Short-time retention of Mathematics concepts	1(11)
7.	Zoning out in Mathematics class	1(12)
8.	Mathematics phobia	3(6,13,16)
9.	Studying for Mathematics test/exam	3(14,21,22)
10.	Inferiority complex	2(23,24)
11.	Recall of Mathematics concepts	3(10,15,20)
12.	Sentences full of Mathematical symbols	1(17)
	Total number of items	**24**

Source: Hopko (2003): Beasley (2001)

Students' mathematics anxiety scores were used to assign them into three groups: low mathematics anxiety group, medium mathematics anxiety group, and high mathematics anxiety group. Using the percentiles of the anxiety scores enabled the researchers to classify students into various levels of anxiety groups. Students whose scores fell between 33% and 67% were considered to be in medium group. Low and high anxiety groups consisted of the students whose scores were in the lower 33% and in the upper 33% of the distribution respectively.

PROCEDURE

Pre-Experimental Activities

Training of Research Assistants: The researcher appointed and trained twelve research assistants; they were trained on the nature and purpose of the Brain-based Instructional Materials. Essentially, the research assistants were needed in the areas of administration of pre-test and post-test, organization and arrangement of research materials.

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).

Data Analysis

Data collected were analyzed using descriptive and inferential statistics.

The research question was answered using mean scores and standard deviations to explain and compare pretest scores of the experimental and control groups in all the criteria measured.

Inferential Statistics of Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance and estimate the impacts of various factors on the dependent variables. The Multiple Classification Analysis (MCA) was used to determine the mean scores of students in various groups. Scheffe post-hoc test was used to determine the source of the significance and see the direction and the amount of variations due to each independent variable.

RESULTS

Table 3: Attitude Mean Scores of Low, Medium and High Mathematics Anxiety Groups

Mathematics Anxiety Group		Attitude	
		X	**SD**
Low	Pretest	54.86	11.15
	Posttest	59.11	11.47
Medium	Pretest	53.48	12.84
	Posttest	55.30	15.03

	Pretest	48.25	21.63
High	Posttest	5.83	18.83

Table 3 showed that the pretest and posttest Mathematics attitude mean scores of students in low, medium and high mathematics anxiety groups were 54.86 and 59.11, 53.48 and 55.30; and 48.25 and 53.83 with standard deviations of 11.15 and 11.47; 12.84 and 15.03; and 21.63 and 18.83 respectively. The result indicated that students with low mathematics anxiety recorded the highest attitude scores, followed by the medium mathematics anxiety while high Mathematics anxiety group obtained the lowest attitude mean scores in Mathematics. 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.

Ho_1: There is no significant main impact of Mathematics anxiety on students' attitude towards Mathematics.

Table 4: Summary of 2 × 3 × 2 ANCOVA of Post-Attitude Mean Scores of Students by Treatment, Cognitive Style and Anxiety Test Score.

Source of Variance		**Experimental Method**				
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig. F**
Covariates	Pre-Attitude Score	4075.624	1	4075.624	23.942	.000
Main Impacts	(Combined)	1536.373	4	384.093	2.256	.062
	Treatment	293.966	1	293.960	1.727	.189
	Cognitive Style	73.383	1	73.383	.431	.512
	Mathematics Anxiety	964.331	2	482.166	2.832	.060
2 – Way Interactions	(Combined)	2177.479	5	435.496	2.558	.027
	Treatment×Cognitive Style	13.320	1	13.320	.078	.780
	Treatment× Mathematics Anxiety	1842.945	2	921.472	5.413	.005*
	Cognitive Style× Mathematics Anxiety	156.944	2	78.472	.461	.631
3 – Way Interactions	Treatment× Cognitive Style.	110.753	2	55.376	.325	.722

	Mathematics Anxiety					
Model		7900.229	12	658.352	3.867	.000
Residual		86818.015	510	170.231		
Total		**94718.245**	**522**	**181.453**		

*Significant at $p < 0.05$

Table 4 showed that there was no significant main impact of mathematics anxiety on students' attitude towards Mathematics ($F_{(2,510)} = 2.83$; $p > 0.05$). This means that students with varying Mathematics anxiety did not differ significantly in attitude towards mathematics. Hence, the null hypothesis 1 was not rejected.

Table 5: Multiple Classification Analysis on Post Attitude Mean Scores by Treatment, Cognitive Style and Mathematics Anxiety.

Grand Mean = 57.14.

Variable + Category		N	Unadjusted Mean	Adjusted for Factors and	Unadjusted Deviation	Eta	Adjusted Deviation	Beta
Treatment	Experimental	281	57.69	57.84	.55	0.44	.70	3.136
	Control	242	56.50	56.33	-.64		-.81	
Cognitive Style	Analytic	192	58.15	57.65	1.00	.057	.51	0.841
	Non-Analytic	331	56.56	56.85	-.58		-.29	10.861
Mathematics Anxiety	High	49	54.37	55.37	-2.78	.128	-1.78	10.861
	Medium	249	55.96	56.06	-1.19		-1.08	
	Low	225	59.06	58.73	1.92		1.59	
Multiple R		0.243						
Multiple R Squared		0.059						

The MCA Table 5 showed the differences among the three mathematics anxiety levels but these differences were not strong enough to bring about significant main impact on anxiety test score in students' attitude towards mathematics. Students with high mathematics anxiety recorded the lowest attitude mean score in Mathematics ($\overline{X}$ = 55.37), preceded by medium mathematics anxiety group ($\overline{X}$ = 56.06) while the low anxiety test score group recorded the highest attitude mean scores in mathematics ($\overline{X}$ = 58.73).

DISCUSSION

From the results, there were no significant main impacts of Mathematics Anxiety on Students' Attitude towards Mathematics. This is possibly due to the nature of treatment used, i.e. Brain-based instructional strategy, which could be less anxiety biased than the content of instruction. This implies that the Brain-Based Learning Strategy could have reduced any possible influence of Mathematics anxiety on attitude towards Mathematics. This position is strengthened by Flewelling and Higginson (2001) who suggest that students can overcome Mathematics anxiety and find learning Mathematics to be a rewarding and successful experience when teachers establish a classroom culture oriented toward making sense rather than a more traditional culture oriented toward memorizing, being correct, recalling quickly and listening.

However, research studies clearly indicate that students performance in Mathematics improves when anxiety is alleviated (Ashcraft, 2002). Teachers alleviate that anxiety when they demonstrate excitement and confidence in the subject-matter, develop a relevant Mathematics curriculum, use effective instructional strategies, create classrooms centered on discovery and inquiry, and assess students in a meaningful and fair manner (Shields, 2005). For attitude towards Mathematics, the finding corroborates those of Tapia (2004) but disagrees with those of Nasser (1998).

In addition, this study indicated that Mathematics anxiety was not a strong variable for determining students' attitude toward Mathematics. The implication of this is that the brain-based learning used proved to be less anxiety biased than the content of instruction.

CONCLUSION AND RECOMMENDATIONS

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.

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. This result confirms the assertion of researchers (Sousa, 2008, 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.

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

i. To improve students' attitude towards Mathematics, innovative strategy such as Brain-Based Instructional Strategy should be adopted in secondary schools.

ii. In the use of this strategy, teachers should not only create learning environments that fully immerse students in an educational experience but also eliminate fear in students, while maintaining a highly challenging environment with emphasis on consolidation and internalization of information in them.

iii. Teachers of Mathematics should be encouraged to make adequate provision of an enriched learning environments, 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 towards Mathematics.

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