INTERACTIVE EFFECT 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 interactive effect 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 Students from nine randomly selected co-educational schools from five Local Government Areas in Oyo State. Five schools were randomly assigned to the experimental (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), Mathematics Anxiety Rating Scale (r = 0.81) and Assessment Sheet for Evaluating Teachers' Performance. One research question guided the study in juxtaposition with one hypothesis. Data obtained from the research questions were analyzed using mean scores while the hypothesis was tested at 0.05 level of significance using the analysis of covariance (ANCOVA). There was a significant interaction effect of Brain-based instructional strategy and mathematics anxiety on students' attitude towards Mathematics.

Brain-based instructional strategy was more effective in improving students' attitude to Mathematics than the conventional method: both the treatment and anxiety worked together to produce a joint impact on students' attitudes. Teachers of Mathematics could, therefore, adopt this strategy for teaching secondary school students. This would go a long way in reducing the fear, *test-phobia* and undesirable attitude in Mathematics among students.

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 (Binda, 2006; 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	173816 (32.79)	164819 (31.09)	338635 (63.88)	191439 (36.12)
2001	1023102	383955 (36.55)	334902 (32.73)	718857 (69.28)	304245 (30.72)

2002	908235	309409 (34.06)	334907 (32.62)	644316 (66.68)	263919 (27.98)
2003	926212	341928 (36.91)	331348 (35.11)	673276 (72.02)	252936 (27.98)
2004	832689	287484 (34.52)	245071 (28.22)	532555 (62.74)	300134 (37.26)
2005	1,054853	402982 (38.20)	267600 (25.36)	670582 (63.56)	384271 (36.44)
2006	1181515	482123(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 fluctuating trend in year 2001 showed that of the 1,023,102 candidates that sat for the examination, only 383,955 (36.55%) scored credit and above while 32.73% representing 334,902 students got pass and 304,245 (30.72%) failed. In 2002, out of 908,235 candidates, 34.06% representing 309,409 students scored credit and above, 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 instruction. 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, 2002); self-regulatory and cooperative learning strategies (Ifamuyiwa, 2005; Ojo, 2003); and computer and text-assisted programmed instruction (Etukudo, 2002; Udousoro, 2000).

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 attitude.

Mathematics anxiety has been explained in terms of a chain reaction or cycle. Spielberger (1972) conceptualized anxiety as a state, trait and a process. As it is described by Spielberger (1972), anxiety is a result of a chain reaction that consists of a stressor, a perception of threat, a state reaction, cognitive reappraisal and coping. Mitchell (1987) described a Mathematics anxiety cycle and stated that Mathematics anxiety experienced in the present has its roots in the past. Anxiety is perpetuated through negative self-talk manifesting in beliefs, which cause anxiety. This leads to physical symptoms, an inability to think and avoidance, which in turn, leads to the inability to perform, causing anxiety and more negative self-talk, and the continuation of the Mathematics anxiety cycle (Mitchel 1987). This cycle leads to negative educational and societal Mathematics attitudes, which often become a self-fulfilling prophecy and generally leads to Mathematics avoidance (Williams, 1988).

Miller, L.D. and Mitchell, C.E. (1994) distinguished between two forms of Mathematics anxiety, being:

- Mathematics test anxiety defined as feelings of nervousness associated with past, present and future mathematical situations.
- Mathematics problem-solving anxiety defined as feelings of nervousness associated with situations in and out of school that require learners to solve Mathematics problems and use the solutions in some way.

Results of studies conducted showed that learners become more anxious about Mathematics testing situations as they progress through school (Miller, L.D. and Mitchell, C.E. 1994).

The beginning of anxiety can often be traced to negative classroom experiences and the teaching of Mathematics (Williams, 1988). It is considered critical to examine classroom practice and establish whether the roots of Mathematics anxiety may be in instructional methods and in the quality of Mathematics teaching in elementary school (Newstead, 1998). Greenwood (1984) stated that the principal cause of Mathematics anxiety lies in the teaching methodologies used to convey basic mathematical skills. He asserted the “explain – practise – memorize” teaching.

From the above, it can be noted that mathematic anxiety includes many aspects. In the following section, information on the causes of Mathematics anxiety will be detailed. 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 psycho-behavioural components. Physical aspects of Mathematics anxiety are biological, consisting of hormonal, chemical and muscular changes in the body, which result 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.

Statement of Problem

This study investigated through quasi-experimental design, the interactive effect 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 posttest mean score of attitude to Mathematics scores of:
(i) low, (ii) medium, and (iii) high mathematics anxiety groups?

Research Hypothesis:
$H0_1$: There is no significant interaction impact of treatment and Mathematics anxiety on students' attitude towards Mathematics.

Methodology
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).

The division of intact classes to different treatments (instructional strategy) was employed because they are believed to consist of natural clusters, having similar age, height, academic background and other attributes. In using this design, two intact groups of participants were randomly assigned to 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.

Five hundred and twenty-two (522) senior secondary school students were involved in this study. Three (3) zones were randomly selected from the four zones that make up the Oyo North Senatorial District of Oyo State. Stratified random sampling procedure was used in selecting nine (9) schools: five (5) schools from urban and four (4) from rural areas of the three (3) zones selected for the study. Five (5) of the schools were randomly assigned as experimental groups and four (4) as control groups. In each of the nine sampled schools, only two (2) randomly selected intact classes (SS II) were involved in the study.

Research Instruments

The following instruments were used in the study:

(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 (20) 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 student's name, age, gender, class and name of school. Section B is made up of twenty (20) items (10 positive and 10 negative statements), requesting participants to indicate their attitude towards the study of Mathematics based on a (4) point Likert scale. Each participant was requested to tick an appropriate option weighted as follows:

Strongly Agreed (SA)	-	4
Agreed (A)	-	
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)

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.

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,

	1	2	3	4	5	
Not at all						Very much

and B. Section A is designed to elicit responses in relation to participants' age, gender and name of school. Section B consists of twenty (24) 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 1: 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 made the classification of the students. Students whose scores fell between 33% and 67% were considered the 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.

Research 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) Attitude Towards Mathematics Questionnaire (ATMQ).

Post-Test Administration

This involved the administration of modified form of research instruments, which were used during the pre-test stage. The two instruments administered after the treatment were:

(i) Attitude towards Mathematics Questionnaire (ATMQ)
(ii) Mathematics Anxiety Rating Scale (MARS)

Data Analysis

The data obtained were analyzed using descriptive and inferential statistics. Inferential Statistics of Analysis of Covariance (ANCOVA) was used to test the hypothesis 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

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.

Table 2: 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
High	Pretest	48.25	21.63
	Posttest	5.83	18.83

Table 2 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 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 scores in Mathematics. 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.

$H0_1$: There is no significant interaction impact of treatment and Mathematics anxiety on students' attitude towards Mathematics.

Table 2: 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 x Cognitive Style	13.320	1	13.320	.078	.780
	Treatment x Mathematics Anxiety	1842.945	2	921.472	5.413	.005*
	Cognitive Style x Mathematics Anxiety	156.944	2	78.472	.461	.631
3 – Way Interactions	Treatment x Cognitive Style. Mathematics Anxiety	110.753	2	55.376	.325	.722
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 2 indicated that there was a significant interaction impact of treatment and mathematics anxiety on students' attitude towards mathematics ($F_{(2,510)} = 5.41$; $p < 0.05$). Therefore, the null hypothesis 1 was rejected.

Figure 1 showed the graphical illustration of the nature of this significant interaction.

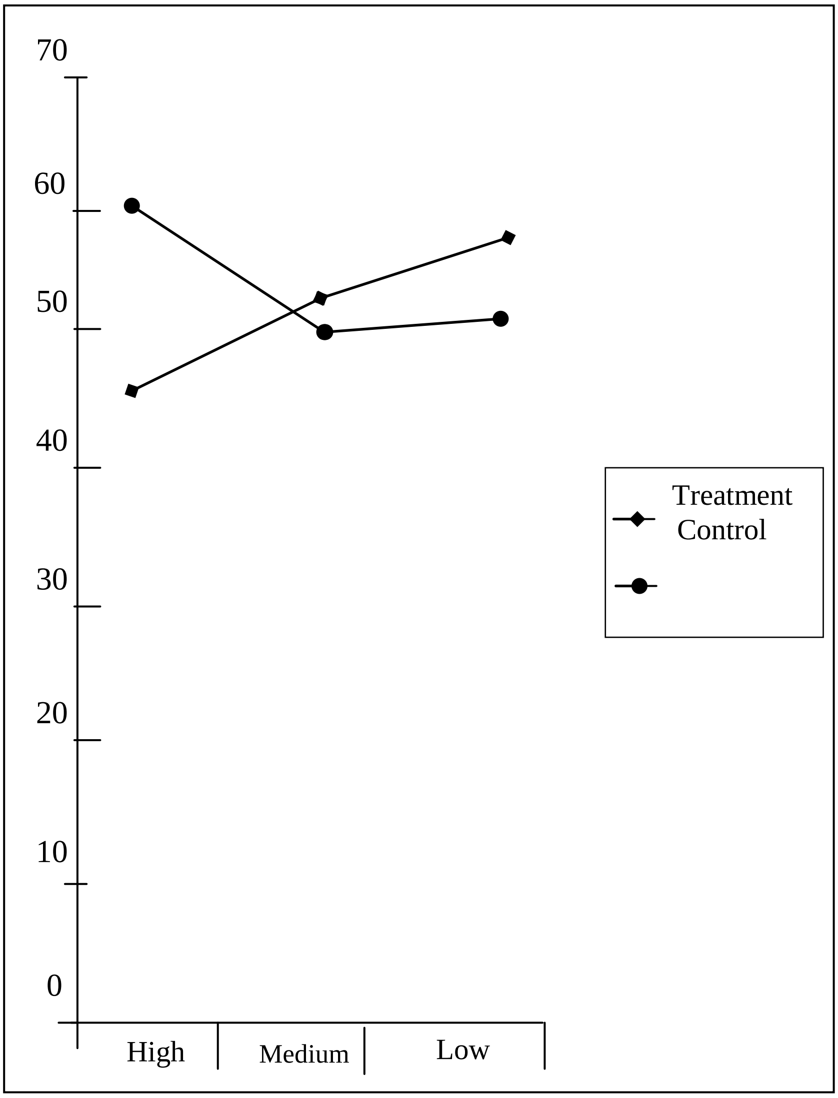

Fig. 1: **Interaction Impact of Treatment and Mathematics Anxiety on Students' Attitudes towards Mathematics**

Within the Brain-Based Learning Strategy group, students with low mathematics anxiety recorded the highest attitude mean scores towards mathematics (x = 60.20) followed by the medium mathematics anxiety group (x = 56.95) while those with high mathematics anxiety recorded the lowest attitude mean score towards mathematics (x = 47.86). In the control group, students with high anxiety test score recorded the highest attitude mean scores towards mathematics (x = 59.67) followed by low mathematics anxiety group (x = 57.62) while those with medium mathematics anxiety obtained the lowest attitude mean score towards mathematics (x = 54.82). This interaction is disordinal. It means both the treatment the anxiety worked together to produce a joint impact on students' attitudes.

Discussion of Results

There was a significant interaction effect of Brain-based instructional strategy and mathematics anxiety recorded on attitude towards Mathematics. This interaction showed the sensitivity of treatment to students' Mathematics anxiety on attitude towards Mathematics. Thus treatment interacted with Mathematics anxiety to produce result on students' attitude towards Mathematics. However, students with low and medium Mathematics anxiety benefited from attitude towards Mathematics more than students with high Mathematics anxiety when brain-based instructional strategy was used. This may have been due to the fact that brain-based instructional strategy is threat-free to students learning and this may have afforded students with low and medium anxiety levels more than the high anxiety level, the opportunity to relax in the classroom thereby lessening their fears towards the teaching-learning process of Mathematics. This finding corroborates the findings of Rahmah (1999) but is at variance with that of Norwood (1994).

However, research studies clearly indicate that student performance in Mathematics improves when anxiety is alleviated (Ashcraft, 2002). Teachers alleviate that anxiety when they demonstrate excitement and confidence in the strategies, create classrooms centred on discovery and inquiry, and assess students in a meaningful and fair manner (Shields, 2005).

Conclusion and Recommendations

This study established 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.

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

1. To improve students' attitude towards Mathematics, innovative strategy such as Brain-Based Instructional Strategy should be adopted in secondary schools.
2. 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.
3. 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 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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