INTERACTION EFFECT OF BRAIN-BASED INSTRUCTIONAL STRATEGY AND COGNITIVE STYLE ON STUDENTS’ ACHIEVEMENT IN MATHEMATICS

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Abstract  
This study investigated the interaction effect of brain-based instructional strategy and cognitive style of students’ achievement in 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 used were: Achievement Test in Mathematics ($r = 0.86$) and Cognitive Style Test ($r = 0.81$).

Three hypotheses were tested at 0.05 level of significance using the analysis of covariance (ANCOVA). The result revealed significant main effect of treatment, $F_{(1,510)} = 75.0; P < 0.5$), cognitive style ($F_{(1,510)} = 5.027; P < 0.05$) on achievement in Mathematics. The result showed that brain-based instructional strategy enhanced students’ achievement in Mathematics more than the conventional lecture method. It is therefore recommended that teachers of Mathematics should adopt the strategy in teaching mathematics in Senior Secondary School. The study also revealed that the cognitive style level of the students is found to be crucial in determining their achievement in Mathematics. Teachers of Mathematics should therefore endeavour to design lesson plans capable of enhancing the performance(s) of students with varied cognitive style levels.
Introduction
Several instructional strategies have been recommended for the teaching-learning process in Mathematics which include the use of personalized system of instruction, (Kadir, 2004; Ku and 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; Ojo, 2003); and computer and test assisted programmes instruction (Etukudo, 2002, Uduosoro, 2000).


According to Hart, L. (1983), 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 also pushes 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).

Brain-based learning strategy is a learner-centred and teacher-facilitated strategy that utilizes learners’ cognitive endowments. Sousa, D.A. (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, D.A. 2004; Ryan, J. and Abbot, J. 1999; Caine, R.N. and Caine, F. 1990; Jensen, E. 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 learning, is an educational approach based on what current research in neuroscience suggests about how our brains naturally learn best (Luna, B. 2004). The learning strategy derived from this research can easily be integrated into any learning environment, from a kindergarten classroom to a seminar for adults (Lucas, R.W., 2004).

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, B. (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 technique or 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. 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 cognitive and affective learning outcomes in Mathematics. Anderson, J.R.; Reder, L.M.; and Simon, H.A. (2003) argues 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 critical cognitive styles.

Student’s cognitive style has been found to mediate learning (Ige, T.A., 1998). Most of the differences encountered in students’ learning could be described in terms of different manners in which students perceive and analyze a stimulus configuration (i.e. their cognitive styles). Each individual responds differently when exposed to a stimulus world. Some act on first impulse, some examine isolated components of what is presented to them before responding while others respond on the basis of contextual or holistic manner (Olajengbesi 2006). This calls for its better understanding by the teacher in the choice and usage of teaching strategies.

Therefore, for learners to gain significantly from classroom interaction, there is a need to consider the cognitive styles of individual learners, and the instructional strategies that are most responsive to particular cognitive styles (Awofala, A.O., 2002). In view of this, Ogundipe, B.D. (2002) maintains that understanding individual learning styles may lead to reduction of teacher and student frustration, thereby enhancing:

- high students’ achievement;
- accommodation of a variety of learners in the classroom; and
- improve communication with administrators, parents, councillors and other staff- Ige, T.A. (1998) concludes that the nature of teaching strategies may tend to encourage to different degrees, students of different cognitive styles.
Most of the studies did not make attempt to find the main and interaction effects of Brain-based learning strategy and cognitive styles on students’ achievement in senior secondary school mathematics. Therefore, this study investigated the interaction effect of Brain-Based Instructional Strategy and Cognitive Styles on students’ achievement in senior secondary school mathematics.

2. Method

2.1 Research Design
The study adopted a pretest-posttest, non-equivalent control group design in a quasi-experimental setting. This design was preferred because the experimental and control groups were naturally assembled groups as intact classes with similar characteristics. Since intact classes were used, it was not possible to administer treatment to equal number of subjects in the two experimental groups.

2.2 Sample and Sampling Technique
Using simple random sampling, one school each was selected from nine randomly picked local Government areas to make a total of nine schools. The Local Government Areas included: Afijio, Akinyele, Iseyin, Oyo East, Kajola, Ogbomoso South, Atiba, Itesiwaju and Orire. Fifty-eight senior secondary year two (SS II) students in Mathematics were randomly selected from each of the schools to make a total of 522 students.

2.3 Research Instruments
Two instruments were used for data collection, namely:
(i) Achievement Test in Mathematics (ATM)
(ii) Cognitive Style Test (CST).

The ATM had 20 essay test items. It had two sections: A and B. Section A sought personal information with respect to age, gender and name of school. Section B consisted of 20 essay test items. Test items covered the three levels of cognitive domain of remembering, understanding and thinking tasks as shown in table 2.
Table 2: Test Items Specifications

<table>
<thead>
<tr>
<th>Content</th>
<th>COGNITIVE LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Remembering</td>
</tr>
<tr>
<td>The Sine and Cosine</td>
<td>1</td>
</tr>
<tr>
<td>Angles of Elevation and Depression</td>
<td>4</td>
</tr>
<tr>
<td>Heights and Distances</td>
<td>7</td>
</tr>
<tr>
<td>Bearings and Distances</td>
<td>14</td>
</tr>
<tr>
<td>Angles between Two Places in the Earth's Surface</td>
<td>18</td>
</tr>
<tr>
<td>Shortest Distance</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
</tr>
</tbody>
</table>

*Note: The figures under Remembering, Understanding and Thinking are item numbers.*

2.4.1 Validation and Reliability of ATM

The ATM was validated based on the contents of topics incorporated into the instructional design, to see how the research instrument covered a representative sample of the content. Initially, a draft of 35 essay items was developed to cover the categories of remembering, understanding and thinking tasks. This draft was validated by four mathematics lecturers at Federal College of Education (Special) in Oyo State, Nigeria, using a checklist consisting of the following:

a) Language clarity to target population;

b) Content coverage in terms of adequacy or otherwise; and

c) Item relevance of the drafted items to the stated objectives.

The test items were scaled down to 25 based on the recommendations of the experts. The validated 25-item essay test was administered to 40 students of a school selected for field testing for one hour. Both discriminating power and difficulty index were calculated. Items of discrimination power of more than 0.40 and difficulty index of 0.40 - 0.60 were retained. Five of the items were eventually dropped leaving the final set of 20 questions for the instrument. A Kuder-Richardson's formula 20 was used (due to similarity in item difficulty levels) to determine the internal consistency and a reliability coefficient of 0.86 was obtained.
2.4.2 Cognitive Style Test (CST)
The CST is a reasoning test for measuring how students choose and analyze sets of pictures of common objects, animals, plants or artifacts for the purpose of classifying them. The language students use in categorizing these phenomena presumably reflects their style of categorization. The CST is a modified version of the CST developed by Awofala, A.O. (2002). The modification and revalidation were done by Onyejiaku, F.O. (1980) to reflect Nigerian environment as cited in Afuwape, M.O. (2002). This study adapted the modified version which consists of twenty cards (of three pictures each) numbered 1 to 20. 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 statements made by the student regarding the way he/she perceives the pictures and classifying any two together could be categorized into three thus:

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

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

(c) **Relational Contextual (RC)** - Students here, place together objects on the basis of feature establishing a relational link between them. Example: students 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 students were those who scored above the media AD and CI responses and below the median on RC responses. Non-analytic style students were those who scored above
the median on RC responses and below the median on AD and CI responses.

2.4.3 Validation and Reliability of CST
Onyejiaku, F.O. (1980) estimated the reliability estimates of items in the CST to range from 0.62 to 0.72. Onafowokan, B.A. (1980) also trial tested the CST using 137 Junior Secondary School III students in four secondary schools in Nigeria. The trial test results showed no ambiguities in the instrument. The results also produced a test-retest (two weeks interval) reliability value of 0.84. For the present study, the CST was trial tested twice (separated by two weeks) using 40 Senior Secondary School II students of the field-testing school in order to further ensure its validity and reliability. A test-retest reliability value of 0.81 was obtained.

2.4.4 Brain-Based Instructional Materials
The BBIM (Brain-based instructional materials) in mathematics were developed based on the findings of two main researchers (Jensen, E. 1998 and Nunley, K. 2004). Their findings showed greatest gain in achievement and attitude with the manipulative materials (right hemispheric) while the textbook approach (left hemispheric) resulted in the least gains. These materials are:

a) "NKPM" (Needful Knowledge Package in Mathematics): This is designed to enable students make meaningful connections and consolidate the gap between the prior knowledge and new information. Copies of the NKPM for the topics selected for the study were distributed to the students to glance through within some minutes.

b) "SKACM" (Students' Knowledge Acquisition Card in Mathematics): This is designed to capture and retain students' attention to a greater extent throughout the learning episode. It was given to the students before the commencement of the lesson. The students were instructed to write the 'summary' of important facts they are able to acquire from the lesson. This was done twice before the end of the lesson: The teacher instructed the students to complete part of the SKACM during the "brain-downshifting" period of the whole learning episode. The latter part was completed at the end of the lesson.
c) "WLTM" (Weekly Learning Terrain in Mathematics): This is designed to engage the students in active processing. The teacher engaged the learners in active processing by guiding them to gain insight into the problem. The learners were allowed to order, structure and relate to the new information at their own pace. Copies of the WLTM were displayed at strategic corners in the classroom and on the mathematics bulletin board for students to interact with.

d) "ICSPM" (Index Card Study Profile in Mathematics): This is designed to cater for all the categories of learners, viz fast learners, slow learners and other prominent individual differences that may exist among the students. Copies of the ICSPM relevant to the topics chosen for the study were made available in a shelf in the classroom. These cards contained key facts on mathematics concepts and definition of terms relating to the current topics. Students were instructed to go at will to the shelf and explore from the enriched learning environments created within the four walls of the classroom.

e) "SEC"/"Q&S" (Self-Evaluation Card): This is designed for spot assessment. The teacher is expected to release the feedback before the commencement of the subsequent lesson. The outcome of the "Q&S" or Students' Performance determines whether the teacher needs to maintain the status quo in the use of his/her strategies or it is mandatory to improve upon his/her strategies towards the actualization of an improved learning outcome in the subsequent lesson. "SEC" containing questions and solution space were given to the students at the appropriate time. All Cards in "Q" portrayed questions that were drawn from mathematics concepts or topics to be taught. All cards in "S" portrayed detailed (step-by-step solutions) to the question(s) on "QS".

2.4.5 Validation and Reliability of BBIM
The BBIM were given to two mathematics experts and one educational technology expert in the Department of Teacher Education, University of Ibadan in Nigeria for: (a) face and content validation in terms of language clarity to the target audience; (b) content coverage; and (c) relevance to the stated objectives and design.
2.5 Research Hypotheses
Three null hypotheses were generated and tested at 0.05 level of significance, they are:

\( H_{01} \): There is no significant main effect of treatment on students' achievement in mathematics.

\( H_{02} \): There is no significant main effect of cognitive style on students' achievement in mathematics.

\( H_{03} \): There is no significant interaction effect of treatment and cognitive style on students' achievement in mathematics.

2.5 Procedure
The regular mathematics teachers in the selected schools who were trained by the researcher were used for the study. Each teacher was given a copy of validated lesson plan as well as copies of the two instruments used for the study. The CST was administered only as pretest and was used for categorizing students into analytic and non-analytic levels of cognitive style. After this, the Achievement Test in Mathematics was administered as a pretest and the scores noted before the treatment commenced.

The main treatment for the study was teaching using the BBIS and it lasted for seven weeks. The experimental group (n = 280) was taught mathematics using the BBIS. This involved the following presentation steps:

a) Link new information to existing knowledge;
b) Relaxed alertness through brain gym exercises which include "drink water"; "cross crawl"; "brain button" and "hook ups";
c) Identify 'prime times';
d) Optimizing learning through different media (music) composed by Jim Reeves was used as a carrier, an arousal, and as a primer;
e) Use of brain-based instructional material to guide and support students' attention, encoding and retrieval process;
f) Peer teaching during the "down time" - fast learners identified using pretest scores and were allowed to teach others, the materials they were learning;
g) Engage the learners in "elaborate rehearsal" through role plays, debates, acronyms and rhymes;
Evaluation of students’ achievement using SKAC and SEC.

The control group (n = 242) was taught the same concepts in mathematics using the Conventional Teaching Strategy (CTS). In using this strategy, the regular mathematics teacher delivered the pre-planned lesson to the students with or without the use of instructional aids. The teacher proceeded to the task of solving the problems without giving the students the opportunity to discover methods of finding solution or principles behind the solution. Interaction between the students and the teacher was minimal and the students listened and assimilated principles and procedures for the correct solution to the problem.

Thereafter, the ATM was administered as a post test to the students in both groups.

2.6 Method of Data Analysis

Data collected were analyzed using Analysis of Covariance (ANCOVA) with the pretest scores as covariates. The use of ANCOVA enabled the researcher to partial out the initial differences from the two groups. Initially, students in both the experimental and control groups were pre-tested on the Achievement Test in Mathematics. Statistical analysis showed no significant difference in pre-test scores of the students. However, analysis of the post-test scores (using Achievement Test in Mathematics as criterion measure) revealed significant difference, so cognitive style test was included as a factor in subsequent analysis.

**Table 3:** Analysis of Covariance (ANCOVA) of Students' Achievement Scores by Treatment and Cognitive Style Levels

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post test score</td>
<td>26563.472</td>
<td>1</td>
<td>26563.472</td>
<td>304.984</td>
<td>.000*</td>
</tr>
<tr>
<td>Covariates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre test score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Effects</td>
<td>66918.527</td>
<td>2</td>
<td>33459.264</td>
<td>384.157</td>
<td>.000*</td>
</tr>
<tr>
<td>(Combined) Treatment Cognitive Style</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### Results

**Hypothesis 1:** There is no significant main effect of treatment on students’ achievement in mathematics.

The result in Table 3 shows a significant main effect of treatment on students’ achievement in mathematics ($F_{(1,510)} = 760.93; P < 0.05$). This clearly indicates that there was a significant difference in the post test achievement means scores of students exposed to the BBIS and those exposed to the CTS. In line with this result, $H_0$ was rejected. The $F$-ratio tests for a difference between variances. The $F$-ratio is a ratio of the two variances, the SSB Sum of Squares between and SSW Sum of the Squares within.

**Sum of Squares:** The total amount of variation for the scores in a study is measured by the Total Sum of Squares (TSS). The value for the TSS can be divided into two components. The first is the amount of variation within each sample, called the sum of squares within (SSW). The second is the amount of variation between samples, called the sum of squares between SSB, $TSS = SSB + SSW$.

Table 3 shows that both the treatment and the cognitive style had significant main effect on students, achievement in Mathematics ($000^*$).

To find out the magnitude of the difference between the experimental and control groups, Multiple Classification Analysis (MCA) was computed and the results are presented in Table 4. This table shows that students exposed to the BBIS obtained the higher adjusted post test achievement mean score ($\bar{X} = 29.44$) than those taught using the CTS. The table also indicates that $67.2\%$ of the variation in students’ achievement in mathematics was accounted for by taking the
independent variable (treatment) and the moderator variable (cognitive style) together.

**Table 4:** Multiple Classification Analysis on Pre-Test Achievement Scores by Treatment and Cognitive Style

<table>
<thead>
<tr>
<th>Variable and Category</th>
<th>Predicted Mean</th>
<th>Deviation</th>
<th>Eta</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N Unadjusted</td>
<td>Adjusted factors and covariates</td>
<td>Unadjusted Covariates</td>
<td>Beta</td>
</tr>
<tr>
<td>Pos Score</td>
<td>Treatment</td>
<td>19</td>
<td>2</td>
<td>.703</td>
</tr>
<tr>
<td></td>
<td>28.0</td>
<td>29.44</td>
<td>11.29</td>
<td>-13.11</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>21.61</td>
<td>3.06</td>
<td>-1.77</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>61.0</td>
<td>-1.77</td>
<td>1.64</td>
</tr>
</tbody>
</table>

Multiple regression .820
Multiple r. squared .672

**Hypothesis 2:** There is no significant main effect of cognitive style on students' achievement in mathematics.

The results in Table 3 show a significant main effect of cognitive style on students' achievement in mathematics ($F_{(1:510)} = 26.69; P < 0.05$). Thus, students with varying cognitive style levels differed significantly in mathematics achievement. Therefore, the $H_2$ was rejected.

To find out the magnitude of the difference in mean scores between the analytic and the non-analytic groups, Multiple Classification Analysis was computed. Table 4 shows that analytic cognitive style group obtained higher achievement mean score ($\bar{x} = 21.61$) than the non-analytic cognitive style group ($\bar{x} = 17.15$).

The effect size or eta squared for each factor is an indicator of the strength of these effects. Table 4 indicates that treatment contributed 74.6% (or eta squared) to the variance observed in students' achievement in Mathematics. Beta-weights or standardized coefficients are calculated to "wash out" the effect of the units of measurement. We can see that (.703) has a slightly stronger "pull" on experimental group than the control group (.132).
Hypothesis 3: There is no significant interaction effect of treatment and cognitive style on students' achievement in mathematics.

Table 3 reveals a significant interaction effect of treatment and cognitive style on students' achievement in mathematics ($F_{(1,510)} = 6.65; P < 0.05$). Therefore, $H_0_3$ was rejected.

The table below shows the graphical illustration of the nature of this significant interaction.

**Interaction Effect of Treatment and Cognitive Style on Students' Achievement in Mathematics.**

Findings showed that there was significant interaction effect of treatment and cognitive style on students' achievement in mathematics. This result confirms the assertion of researchers (Olajengbesi, 2006 and Awofala, A.O.A. 2002) that the personal variable of cognitive style interacts with instruction to produce results.

This implies that the treatment is sensitive to students' cognitive style on achievement in mathematics. In other words, understanding and utilizing the core principles of brain-based instructional strategy to teach students of different cognitive style in order to achieve the desired learning outcomes becomes inevitable.

Also, analytic cognitive style students more than non-analytic are very critical in their reasoning and are able to distinguish figures as discrete from their background, and this may have enhanced their achievement in mathematics.
4. Discussion

The results of this study obviously exhibited significant main effect of treatment \((F_{(1,510)} = 760.93; P < 0.05)\), cognitive style \((F_{(1,510)} = 26.69; P < 0.05)\), and interaction effect of treatment and cognitive style \((F_{(1,510)} = 6.65; P < 0.05)\) on students' achievement in mathematics.

These results showed that brain-based instructional strategy enhanced students' achievement in Mathematics better than the conventional method. The relative effectiveness of the brain-based learning strategy over the conventional method could be due to the fact that brain-based learning strategy is a learner-centred instructional strategy which provides learners with the opportunity for orchestrated immersion-creating learning environments that fully immersed learners in an educational experience.

In this study, the teacher became the orchestrator or the architect, designing experiences that led students to make meaningful connections by using various combinations of experience, reflection, conceptualization and experimentation. The learners were immersed in complex, multiple interactive and authentic experiences that were both real and rich. This enabled the learners to solve realistic mathematical problems thus gaining true access to knowledge which requires them to make meaning from information. The generation of coherency and meaning from information indicates that learning can be enhanced in an environment of total immersion. Interaction of the brain with its environment suggests that the more enriched the environment, the more enriched the brain. The better performance of the brain-based learning group over the conventional group suggests that the strategy offers opportunity for improving memory, increasing focus, boosting awareness, and making studying more fulfilling.

Another reason for the presence of significant effect of brain-based learning strategy on students' achievement in mathematics may be associated with the opportunity for relaxed alertness created in the study. Relaxed alertness entails eliminating fear in learners while maintaining a highly challenging learning environment. In this study, the teacher created a relaxed alertness-learning environment by engaging the learner in "brain gym" exercises. These include "drink water", "cross crawl", "brain buttons" and "hook ups". It is evident that learning can be hindered due to dehydration. The rate of perspiration increases when one is under stress and this leads to dehydration, which affects concentration negatively. In this study, learners were...
encouraged to "drink sizeable quantity of water" before and during class. Physical movements like "Cross crawl" (crossing the arms to touch the knees) which help coordinate the right and left brain by exercising the information flow between the two hemispheres and "brain buttons" i.e. applying pressure on specific points near the neck to stimulate blood flow to the brain which in turn helps to improve concentration skills and "hook ups" i.e. crossing the arms and legs in a way that automatically calms the mind and improves concentration and learning potential were all carried out before and after the class (Sousa, D.A. 2006).

Still creating a relaxed-alertness learning environment and energizing the brain, the teacher played positive and solemn music (Jim Reeves, Vol. 7) prior to the beginning of the class, low volume/solemn background music during class period without overpowering teaching while upbeat music was played to close the class. It is evident that the brain is a pattern maker and takes great pleasure in taking random and chaotic information and ordering it (Caine, R.N. and Caine, G. 1990). In this study, learners were able to process information and create mental patterns by ordering, structuring and relating to the new information using graphic organizers.

However, the brain-based learning strategy allows students to learn at their own level, in their own learning style and it also demands the highest accountability standards thus making learning faster, easier and fun. This finding corroborates the earlier findings of Sousa, D.A. (2006) and Jensen, E. (1998) which established that brain-based learning strategy improved learners' achievement in mathematics.

From the results, there was significant main effect of cognitive style on students' achievement in mathematics. The presence of cognitive style effect on mathematics achievement in this study is consistent with the results of other researchers (Adeyemi, M.A. 1987 and Agina-Obu, T.N. 1991) but at variance with that of (Ige, T.A. 1998).

Students' Cognitive Style was found to have contributed significantly to the variation in scores in mathematics. Hence, analytic cognitive style students outscored their non-analytic cognitive style counterparts in mathematics achievement. This may have been due to the nature and effectiveness of the analytic cognitive style students over their non-analytic cognitive style counterparts in mathematics.

Findings showed that there was significant interaction effect of treatment and cognitive style on students' achievement in
mathematics. This result confirms the assertion of researchers (Olajengbesi, 2006 and Awofala, A.O. 2002) that the personal variable of cognitive style interacts with instruction to produce results. This result implies that the treatment is sensitive to students’ cognitive style on achievement in mathematics. Analytic Cognitive Style students, more than Non-analytic, are very critical in their reasoning and are able to distinguish figures as discrete from their background and this may have enhanced their achievement in mathematics.

Based on the findings of this study, the effectiveness of brain-based instructional strategy in achieving optimal knowledge acquisition and high performance in mathematics has been established. This study has also shown the inherent weakness of the conventional method as a means of enhancing learning in mathematics. While the conventional method is typical of the mathematics classes, the poor performance of students in mathematics may not have been unconnected with over dependency on conventional method of instruction which is grossly inadequate.

4.1 Conclusion
The effectiveness of brain-based instructional strategy in this study lies in the fact that, it is based on the principles of relaxed alertness, orchestrated immersion and active processing. The implication of the findings of this study to educational practice is that brain-based instructional strategy as part of the mathematics curriculum reform is likely to make learning more contextual and engage learner in decision-making, forming cooperative groups, locating resources and applying the knowledge. However, providing students with an enriched learning environment will not only close the windows of learning disabilities but also enhance students’ retentive memory because they will acquire an appreciation of scientific and mathematical key concepts from the beginning. Students will no longer be passive recipients of knowledge but acquire it through collaborative efforts.

Furthermore, since the cognitive style level of the students was found to be crucial at determining their achievement in mathematics, teachers of mathematics should endeavour to design lesson plans capable of enhancing the performance(s) of students with varied cognitive style levels. This is because the results of the study showed that mathematics achievement gain resulting from brain-based instructional strategy was sensitive to students' cognitive style.
4.2 Recommendations

Based on the findings of this study, the following recommendations are made; to improve students' achievement in mathematics and a stable performance of secondary school students in Certificate Examinations/other categories of examinations in mathematics globally, innovative strategies such as brain-based instructional strategy should be adopted in secondary schools. 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.

Practising teachers and teachers in training should be acquainted with the use of brain-based instructional strategy in order to improve their classroom practices and enhance students' achievement in mathematics.

References


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