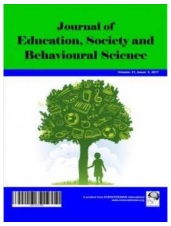

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Effectiveness of Brain-based Learning Strategy on Students' Academic Achievement, Attitude, Motivation and Knowledge Retention in Electrochemistry

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Authors' contributions

This study was carried out in collaboration between both authors. Author JGU handled the theoretical and empirical literature reviews, designed the study, performed the field work, performed the statistical analysis of the data collected, wrote the protocol and first draft of the manuscript while author KJJ also managed the literature researches and analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study was to examine the effect of Brain-Based Learning strategy on students' academic achievement, attitude, motivation and knowledge retention in Electrochemistry. The study used a pretest-posttest quasi-experimental design. A total of 87 Senior Secondary Two students from two intact classes from North-Eastern part of Nigeria with an average age of 17 years of 2015/2016 academic session participated in this study. One of the classes served as the experimental group that used Brain-Based Learning (N=40) while the other was control group that used Lecture-Based Teaching method (N=47). Data were collected through achievement test, attitude and motivation scales. The data collected were analyzed with means, independent t-test, and Analysis of Covariate which were used to compare the groups' scores. The findings of the

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study revealed that the Brain-Based Learning approach used in the experimental group was more effective in increasing student achievement, attitude and motivation of students towards chemistry than the Lecture-Based approach used in the control group. It was identified that the difference between retention test scores were also statistically significant in favour of experimental group.

Keywords: Brain-based learning; electrochemistry; academic achievement; attitude; motivation; knowledge retention.

1. INTRODUCTION

Brain-Based Learning instructional strategy is a learner-centered and teacher-facilitated strategy that utilizes learners' cognitive endowments [1]. This instructional strategy is based on the structure and functions of the brain in different aspects such as learning, assimilating, thinking and remembering. Lucas [2] asserted 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 [1]. Brain-Based Learning 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 [1]. It is a method for developing creative solutions to problems. It is an open sharing activity which encourages all students to participate. The advantage of this method is by expressing ideas and listening to what others say: students can adjust their previous knowledge, and accommodate new information and increase their levels of awareness. They can participate since almost all the answers are accepted. Sousa [3] 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.

Brain-Based Learning (BBL) involves accepting the rules of how the brain processes, and then organizing instruction bearing these rules in mind to achieve meaningful learning [4]. BBL is a way of thinking about the learning process. It is a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process [5]. According to Zull [6], the art of teaching must be the art of changing the brain. Kolb and Kolb [7] opined meaningful learning does not occur in a single way, but in a unity of circulation because the brain works in a unity while learning. This was the reason why Duman, [8] opined that teaching should start with the exploration of the brain.

The objectives of brain research studies include teaching to individual differences, diversifying teaching strategies, and maximizing the brain's natural learning processes [8,9]. Proponents of brain-based instructional strategy [3,9,10,11,12 &13] 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 [1].
(ii) Orchestrated Immersion: This is a technique of trying to eliminate fear in learners, while maintaining a highly challenging environment [1].
(iii) Active Processing: This technique allows the learners to consolidate and internalize information by actively processing it [1].

Based on the findings of neuroscience according to Duman [8], BBL guides according to the principles and workings of the brain to improve the best way of learning, increase academic achievement, and provide equal opportunities for individual differences. According to Jensen [5], Brain-Based Learning was related to teaching strategies and principles from an understanding of how the brain functions and learning with the brain in mind. Another research on Brain Based Learning theory was that of Jensen [5] that drew from multiple disciplines such as Chemistry, Biology, Genetics and Neurology. Brain-Based Education considered how the brain learns best and encouraged educators to take this information into consideration as they planned teaching strategies with the goal of more effectively motivating all types of learners and enhancing positive attitudes in science classroom.

Attitudes and motivations are some of the major factors affecting the quality of learning. Attitudes can be associated with science (and chemistry in particular) and students' due to its abstract nature and misconception. When scientific attitudes are promoted in science classrooms, there will be an increase in students' attitudes towards science [14]. Studies conducted on attitudes by Kocabaş [15], revealed that the attitudes acquired at early ages were not easily changed unless they were very important experiences; while that of Jack [16], revealed that students with positive attitude towards chemistry had higher scores in chemistry tests. Development of positive attitudes in students as opined by Martin, et al. [17], ensures effective learning that would be more meaningful and retentive.

Motivation of students' towards science is also a very important variable in success of learning outcomes. This is because highly motivated students tend to show more academic efforts and perseverance and achievement than low motivated students in classroom activities and tasks [18]. Individuals' time spent to learn a subject, showed that the degree of their motivation towards that subject [19]. It was determined that the factors affecting students' motivations in science education included the interests of students towards subjects, their notes which were taken in classroom, students' perceptions of task, success and failures of obtaining scientific knowledge, the general aim and orientations of students in science and understanding of scientific achievements [20].

The national policy on education [21] stresses that science education must be strengthened so as to develop in the child some well defined abilities and values like spirit of inquiry, creativity, objectivity, courage to question and aesthetic sensitivity. Our understanding of the brain as opined by Remadevi [22], gives positive hope for all students, substantiates broad as well as specific aims, and gives reasons to forge connections between and among prior and new learning situations. Remadevi [22], is also of the view that the teaching-learning process that goes on in schools, not only fails to be brain-compatible, but is actually brain antagonistic since the brain functions best with adequate time, the absence of threat, immediate feedback, dynamic interaction, with global contexts as well as delineation of parts, and in a state of relaxed alertness. Brain-Based learning suggests that teachers must immerse learners in complex, interactive experiences that are both rich and real and students must have a personally meaningful challenge that can stimulate their minds to the desired state of alertness [22]. The text-book based teaching and learning process in a conventional teaching method may habituate the students to learn through verbatim reproduction of the content unlike the BBL teaching method, may replace verbatim reproduction of content with the meaningful understanding through concept-based teaching and learning in an active environment [22]. This was why Jesen [23] opined that; "Nature's biological imperative is simple: No intelligence or ability will unfold until, or unless, it is given the appropriate model environment."

Brain-Based Learning strategies effectively created student success which in turn created a positive student perception. Brain-Based Learning strategy also deals with perceptions of different learners so that their negative perceptions and low expectancy were eradicated. The instructional method failure and ineffectiveness accompanied with students' poor academic performance due to negative attitudes and low motivations towards chemistry is a gap that exists in chemistry education in Nigeria generally and North-Eastern part of Nigeria in particular which this study intends to fill. This study compared the effectiveness of conventional lecture-based teaching method with the BBL teaching method on understanding chemical concepts (Electrochemistry); and its influence on improving students' attitude and motivations towards chemistry and also knowledge retention in Electrochemistry. Therefore, this study aimed to investigate the effectiveness of Brain-Based Learning (BBL) on chemistry students' academic achievement, attitude, motivation and knowledge retention in Electrochemistry at secondary level in North-Eastern part of Nigeria.

1.1 Research Questions

To guide this study, the following research questions were raised and answered.

i. Is there any significant difference in pre-test and post-test mean achievement scores between students taught electrochemistry using brain-based learning and lecture-based teaching methods?
ii. Is there any significant difference on the experimental and control groups' pre-test and post-test mean achievement scores on students' attitudes towards chemistry?
iii. Is there any significant difference on the experimental and control groups' pre-test

and post-test mean achievement scores on students' motivation towards chemistry?

iv. Is there any significant difference in the retention of chemical knowledge between students taught Electrochemistry using Brain-based learning and lecture-based teaching methods?

2. MATERIALS AND MATERIALS

The design of the study is a pre- and post-test experimental model with a control group. The present study compares the effects of independent variables of the study Brain-based learning approach used in the experimental group, and Lecture-based teaching, used in the control group on the dependent variable (student achievement).

2.1 Study Group

A total of 87 Senior Secondary Two (SS2) students of 2015/2016 academic session from two intact classes from North-Eastern part of Nigeria with an average age of 17 years, participated in this study. One of the classes served as the experimental group that used BBL model (N=40: 27 males and 13 females) while the other was the control group that used LBT (N=47: 28 males and 19 females).

2.2 Pre-treatment Procedure

1. This study was carried out during a course on Electrochemistry (electrolysis). For both groups, the study was carried out during a five class-hour week over a six week period. Teaching of the topics in the experimental groups was performed in the following sequences adapted from the works of Opateye [24]:
   - Week 1: Introduction to Electrochemistry: Electrolytes and Non-electrolytes (Module 1)
   - Week 2: Electrochemical Series and Preferential discharge of Ions (Module 2)
   - Week 3: Faraday's Law of Electrolysis (Module 3)
   - Week 4: Oxidation and Reduction (Module 4)
   - Week 5: Electrode Potential and Electrochemical Cells (Module 5)
   - Week 6: General Evaluation
2. A weekly lesson plan was developed on each Module.
3. Ten multiple choice questions where generated for each module given a total of fifty (50) questions or items for the five modules on Electrochemistry with the marking guide.
4. A pre-test was administered to the groups to equalize their pre-knowledge about the topics to be taught in Electrochemistry to ascertain the psychometric properties of the test items (difficulty, discrimination indices and reliability coefficient).
5. The items on each module would be sorted into low and high difficulty levels using these categorization processes:
   Low difficulty level: Difficulty indices range from 0.50-0.99, labelled M_{A1}, M_{B1}, M_{C1}, M_{D1} and M_{E1} respectively for each of the five modules.
   High difficulty level: Difficulty indices range from 0.00-0.49, labelled M_{A2}, M_{B2}, M_{C2}, M_{D2} and M_{E2} respectively for each of the five modules.
6. The Chemistry teachers (Research assistants) would teach each module per week following the lesson plans for each module for a period of five weeks prepared by the researcher while the 6^{th} week would be general evaluation.
7. BBL which is student-activity-centred were used in the experimental group while the traditional teaching approach which is teacher-activity-centred was employed in the control group.
8. By using Attitude toward the Subject of Chemistry Inventory (ASCI), the attitude of the participants towards chemistry was determined. Students were given detailed instructions on how to complete the questionnaire (ASCI) and how to record their answers. The researcher adapted the 8-item Attitude toward the Subject of Chemistry Inventory (ASCI) which was developed by Bauer [25] and modified it to 12 items.
9. After the study was completed, the test used as pre-test was again administered to both groups as a post-test.

2.3 Data Collection Tools

2.3.1 Electrochemistry Achievement Test (EAT)

The instrument for data collection was the Electrochemistry Achievement Test (EAT). The EAT was fifty (50) multiple-choice questions or items for the five modules on Electrochemistry

Table 1. Design for the study

Group	Pre-test	Treatment	Post-test	Retention test
Experimental (BBL)	T_1– A_1–M_1	X	T_1– A_1–M_1	T_1
Control (LBT)	T_1– A_1–M_1	–	T_1– A_1–M_1	T_1

Where: T_1 is Electrochemistry Achievement Test
A_1 is Attitude scale
M_1 is Motivation Scale
X is treatment package Brain-Based Learning (BBL) strategy
BBL: Brain-Based Learning and LBT: Lecture-Based Teaching

which is an SS2 (11^{th} grade) topic in the Nigerian Chemistry curriculum. In each test item, the correct answer was determined as “1” point and at this state the highest point was determined as “50” point given a minimum score of ‘0’ or 1 and maximum score of 50. The instrument, EAT was validated by chemistry experts to verify content validity in terms of scope, relevance, and clarity and simplicity of language/usage. The instrument (EAT) KR-20 reliability value of achievement test was 0.76 while the total distinctiveness was 0.52 and total difficulty value was calculated as 0.55.

2.3.2 Attitude scale: Attitude toward the Subject of Chemistry Inventory (ASCI)

Attitude scale used for this study was Attitude toward the Subject of Chemistry Inventory (ASCI) adapted from that of Bauer [25] and modified by the researcher to 12 items; to determine attitudes of students towards chemistry. In triple Likert scale, answers of students were classified from the most negative to positive, “never”, “sometimes” and “always” as 1, 2 and 3 respectively given a minimum score of 12 and maximum of score 36. The instrument, Attitude Scale, was validated by experts to verify content validity in terms of scope, relevance, and clarity and simplicity of language/usage; in order to determine attitudes “positive or negative” of students towards chemistry. The Attitude Scale reliability value was determined with Cronbach Alpha (α) with a reliability coefficient of 0.78.

2.3.3 Motivation scale

Motivation scale which was developed to determine motivations of students towards chemistry course consists of 15 items. In triple likert scale, answers of students were classified from the most negative to positive, “never”, “sometimes” and “always” as 1, 2 and 3 respectively given a minimum score of 15 and maximum of score 45. The instrument, Motivation Scale was validated by experts to verify content validity in terms of scope, relevance, and clarity and simplicity of language/ usage in order to determine students’ motivations “high or low” towards chemistry. The Motivation Scale reliability value was determined with Cronbach Alpha (α) with a reliability coefficient of 0.82.

2.4 Treatment Procedure

In the experimental group, which consisted SS2 (11^{th} grade) with an average age of 17 years of 2015/2016 session participated in this study. The treatment was administered by the researchers and help of the class chemistry teachers were the research assistants trained on BBL Model six days for a period of two weeks before the administration of treatment. In the experimental group, films and slide shows about how the brain functions were shown. A content-methodology connection designed and developed by Duman [8], according to the BBL model was used for this study. This model represents a learning-teaching design based on conditions, processes, and gains that are connected to each other in a complementary manner. This design stemmed from the BBL principles and conditions outlined by many researchers [26,5, and 27]. This model adopted from Duman [8] consisted of three vertical and horizontal frameworks. The vertical axes represented “the conditions of BBL”, the “learning-teaching process” based on these conditions, and the “learning gains” at the end of this process. The horizontal axes represented elements concerning how the three conditions of BBL are fulfilled in the learning-teaching process. With the use of these elements, gains related to each condition of BBL are obtained. Now, this process can be explored as follows:

I. For “Relaxed Alertness”; 1. The lesson started with music. 2. The required setting for a positive academic perception of self–concept based on principles such as “every brain is unique and it has unique learning and interpretation capacity” and the "brain is a parallel processor" was provided. 3. During breaks, students were advised to drink water. 4. Cooperation and group-work opportunities were provided to enhance emotional awareness and relaxation. Students were also allowed to walk around the classroom to discuss freely and brainstorm. 5. The students were told that each individual is responsible for him/her to both remove stress and to challenge themselves; and they prepared their own portfolios and evaluated themselves to determine their own abilities and capabilities. Throughout the learning-teaching process, a classroom setting with "physiological safety" and "psychological relaxation" was created. The teacher also created a relax alertness learning environment by engaging the learner in "brain gym," "drink water", "brain buttons, etc." exercises and; learners were encouraged to drink a minimal quantity of water before and during class in this study which was a great fun and motivator to students as being experienced the first time in the classroom environment. It is evident that learning can be hindered due to dehydration [28]. The rate of perspiration increases when one is under stress and this led to dehydration which affects students' concentration negatively [28].

The basic concepts and topics in the unit "Electrochemistry" were taught in sub-topics in five modules: Electrolytes and Non-electrolytes (Module 1); Electrochemical Series and Preferential discharge of Ions (Module 2); Faraday's Law of Electrolysis (Module 3); Oxidation and Reduction (Module 4); and Electrode Potential and Electrochemical Cells (Module 5) respectively and; factors such as students' exam scores, heights, weights, and the temperature of the classroom were considered not to bias or distort the results of the study. Based on these scores, activities were carried out with many different assessment tools according to the principles of "relaxed alertness."

II. For "Orchestrated Immersion"; 1. For "focusing on meaningful content" and individual experiences, unit topics were projected. 2. For "integrated program and thematic teaching", the main and sub-themes of the unit topics were determined together with the students from their SS2 chemistry curriculum syllabus.

III. For Active processing: 1. For "questioning and deep thinking", "Asking question is the basic condition required to think", "If there is a question, then there is a meaning" principles were exploited throughout the whole experimental process while the activities were being done. 2. For "internalization and rearrangement of the content", students with different achievement levels were brought together. Activities were performed according to the achievement levels; that is high and low achievers of each group. 3. For "assigning meaning and personal analogies"; topic-related stories were told, educational games were played, crossword puzzles were solved, and drama activities were performed most especially for Modules 1, 2 and 4; Electrolytes and Non-electrolytes; Electrochemical Series and Preferential discharge of Ions; Oxidation and Reduction respectively. The students really found this stage very fascinating and interesting and their perceptions towards electrochemistry which they found very difficult from the pretest results became more positive as they were actively engaged. 4. For "encoding and connecting", all the five modules students were guided in this stage to learn to connect concepts to internalize the lessons learnt in Electrolytes and Non-electrolytes (Module 1); Electrochemical Series and Preferential discharge of Ions (Module 2); Faraday's Law of Electrolysis (Module 3); Oxidation and Reduction (Module 4); and Electrode Potential and Electrochemical Cells (Module 5) respectively. They were able to formulate models to enable them to encode and connect these concepts learnt. The lesson ended with a few questions aiming to remind the students of the topic of the following lesson and to arouse interest and curiosity.

In the control group, a lecture-based teaching method that was teacher-activity-centred was employed, and approaches used in the experimental group were not capitalized upon. The content in the control group was the same as the content dealt with in the experimental group and lecturing and question-answer methods were used to do the activities. Before and after the experimental process; achievement test, attitude and motivation scales were implemented as pretests-posttests to experimental and control groups. Four weeks later after the experimental implementation process (close to the end-of–term examinations), the achievement test was implemented again as retention test to both two groups to determine students' knowledge retention.

2.5 Method of Data Analysis

The statistical tools used for the data analysis were means, standard deviations, t-test and Analysis of Covariance (ANCOVA); where the covariate variable was pretest to control for variations in the students' prior knowledge of Electrochemistry. Means of pretest and posttest scores were used to answer the research questions; while ANCOVA and independent t-test was used to test the hypotheses at 0.05 level of significance. The Statistical Package for Social Sciences (SPSS) 17.0 was used to conduct an ANCOVA to determine if the post-test scores differ between students exposed to BBL and those exposed to the traditional lecture approach; and also ascertain if the methods of instruction produced a significant effect on the posttest achievement scores of students when covariate effect (pretest) was controlled. The independent t-test was to determine students' knowledge retention.

3. RESULTS

Answering Research Question one: Is there any significant difference in pre-test and post-test mean achievement scores between students taught Electrochemistry using Brain-based learning and lecture-based teaching methods?

Table 2 showed the mean pre and post-test achievement scores of the experimental and control groups as 10.57 and 34.76; and 9.97 and 27.51 respectively with mean gain scores of 24.19 for the experimental group and 17.54 for the control group. To verify the difference between the two means in the post-test was statistically significant, Analysis of Covariance (ANCOVA) was used was used as shown in Table 5; the ANCOVA comparison of posttest achievement scores of Brain-based learning and Lecture-based teaching methods. As seen in Table 5, $t_{(87)} = 5.76$, $p = 0.000$ significant at $p \leq .05$, the results of the analysis indicated that the treatment, BBL used in the experimental group was significant positively on students' academic achievement. The results revealed that the methods of instruction produced a significant effect on the posttest achievement scores of students when covariate effect (pretest) was controlled. The result indicated that the treatment, using Brain-based learning settings accounted for the difference in the posttest achievement scores of the students. This implies that a significant difference existed between the two groups of Brain-based learning and Lecture-based teaching methods; in favour of BBL.

Answering Research Question Two: Is there any significant difference on the experimental and control groups pre-test and post-test mean achievement scores on students' attitudes towards Chemistry?

As shown in Table 3, the mean pre and post-test achievement scores of students regarding their attitude towards chemistry in the Experimental and Control group as 9.96 and 30.11; and 8.89 and 20.00 respectively with mean gain scores of 21.15 for the Experimental group and 11.11 for Control group; showing that BBL improved students' attitude more. To verify the difference between the two means in the post-test was statistically significant, Analysis of Covariance (ANCOVA) was used and Table 5 showed the results for the covariance analysis. As seen in Table 5, the result of the analysis of covariance using the pretest scores of students in the two achievement levels as covariates. The result showed that p- value of .001 is less than for the main effect, was not significant at 0.05 alpha level ($t_{(87)} = 5.14$, $p < 0.05$). This means that Brain-based learning was more effective than Lecture-based teaching at increasing students' attitude towards chemistry learning.

Table 2. Mean pre and post-test achievement scores of the students taught using Brain–based learning (Experimental) and Lecture–based teaching (Control)

Instructional approach	N	Pretest		Posttest		Mean gain score
		Mean	SD	Mean	SD	
Brain–based learning	40	10.57	4.40	34.76	21.76	24.19
Lecture–based teaching	47	9.97	3.86	27.51	7.45	17.54

Table 3. Experimental and control groups pre-test and post-test mean achievement scores on students' attitudes towards Chemistry

Group	N	Pretest		Posttest		Mean Gain score
		Mean	SD	Mean	SD	
Experimental	40	9.96	4.35	30.11	5.87	21.15
Control	47	8.89	4.87	20.00	5.23	11.11

Table 4. Experimental and control groups pre-test and post-test mean achievement scores on students' motivations towards Chemistry

Group	N	Pretest		Posttest		Mean Gain score
		Mean	SD	Mean	SD	
Experimental	40	13.93	4.72	33.41	6.77	19.48
Control	47	13.95	4.35	24.71	6.15	10.76

Answering Research Question Three: Is there any significant difference on the Experimental and Control groups pre-test and post-test mean achievement scores on students' motivation towards Chemistry?

As seen also in Table 4, the mean pre and post-test achievement scores of students regarding their motivation towards chemistry in experimental and control groups as 13.93 and 33.41; and 13.95 and 24.71 respectively with mean gain scores of 19.48 for Experimental group and 10.76 for Control group. This showed that the experimental group benefited more from the Electrochemistry lesson using BBL; and that BBL increased the learning motivation of the students taught Electrochemistry. To verify the difference between the two means in the post-test was statistically significant, Analysis of Covariance (ANCOVA) was used and Table 5 showed the results for the covariance analysis. The result showed that p- value of .011 was lesser than for the main effect was not significant at 0.05 alpha level ($t_{(87)}$ =6.60, p< 0.05). This means that there is a significant difference in the mean achievement scores on students' motivation towards Chemistry in favour of the experimental group that used Brain-based learning.

Answering Research Question Four: Is there any significant difference in the retention of chemical knowledge between students taught Electrochemistry using Brain-based learning and lecture-based teaching methods?

To verify the difference between the two means in the post-test was statistically significant, an independent t-test was used as shown in Table 6.

It can be seen in Table 6 that there is a significant difference between the retention test scores of experimental and control group in favor of experimental group (t(85)= 8.45, p=.000 *p<.05). The results showed that the experimental group which had engaged in Brain-based learning produced a higher overall improvement in scores on the Electrochemistry delayed retention test scores used to determine students' knowledge retention. As seen in this result, Brain-based learning, which was implemented to experimental group, provided more retentive learning.

4. DISCUSSION

The findings related to the mean achievement scores of students in the experimental and control groups in the pre-test and post-test on their academic achievement was shown in Tables 2 and 5. The findings revealed that students in the experimental group, who were taught via brain-based learning activities, had higher scores in the posttest scores in Electrochemistry than the control group, who were taught using Lecture-based teaching methods included in the curriculum which was teacher-centred. The results from the analysis indicated that the treatment, BBL used in the experimental group had more positive effect on students' academic achievement. The results revealed that the methods of instruction produced a significant effect on the posttest achievement scores of students when covariate effect (pretest) was controlled. The result indicated that the treatment, using Brain-based learning settings accounted for the difference in the posttest achievement scores of the students. The experimental group students' academic achievement post-test scores were compared with those of the control group. BBL had more

Table 5. Analysis of covariance (ANCOVA) of posttest mean achievement scores on academic achievement, attitude and motivation on experimental and control groups

Source of variations	Sum of squares	df	Mean squares	F-Cal	Sig	Decision
Corrected Model	24813.6	4	6203.40	5.98	.000	
Intercept	4397.34	1	4397.34	13.58	.000	S
Covariate (Pretest)	76.75	1	76.75	6.35	.087	NS
Main Effect (Treatment)	186.70	1	186.70	5.76	.000*	S
Attitude	169.30	1	169.30	5.14	.001*	S
Motivation	213.85	1	213.85	6.60	.011*	S
Error	9908.88	82	120.84			
Total	39666.42	87				

**significant at p ≤ .05; S= significant, NS=Not significant*

Table 6. Independent t-test results regarding retention test scores of experimental and control group

Group	N	Mean	SD	df	T	P	Decision
Experimental	40	36.66	2.62	85	8.45	.000*	Rejected
Control	47	26.71	2.19				

**significant at p ≤ .05*

significant effect on students' academic achievement when compared to Lecture-based teaching method. This implies that a statistical significant difference existed between the two groups. This finding supported empirical related reviewed literatures from science educationists [4,29,30,27,31,40,8,41,42,22 & 43]. The findings also agreed with the statement of Jesen [23] who opined that "Nature's biological imperative is simple: No intelligence or ability will unfold until or unless, it is given the appropriate model environment"; which was adequately demonstrated in BBL.

The findings related to the mean achievement scores of students in the experimental and control groups in the pre-test and post-test on their attitudes towards chemistry was shown in Tables 3 and 5. The findings revealed that students in the experimental group, who were taught via brain-based learning activities, had higher scores in the posttest on their attitudes towards chemistry than the control group, who were taught with the activities based on the lecture methods included in the curriculum. It was observed that the brain-based learning activities had a statistically significant effect on improving the students' attitudes [44, 51 & 41]. The result also confirms the assertion by Adebayo [52], 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 lecture method. Contrary to the findings of this study, the works of Getz, Aydın, Samur & Yıldırım [35,53,54 & 55] revealed that the Brain-based learning approach neither had an influence on students' attitudes towards chemistry nor led to changes in their attitudes.

The findings related to the mean achievement scores of students in the experimental and control groups in the pre-test and post-test on their attitudes towards chemistry was shown in Tables 4 and 5. The findings revealed that the students in the experimental group, who were taught via brain-based learning activities, had significantly higher scores in the posttest on their motivation towards Chemistry than the control group, who were taught with Lecture-based teaching that is teacher-activity-centred. It was observed that the brain-based learning activities were significantly effective in increasing the students' motivation. Similarly, Salmiza [56] and Akyürek, & Afacan [41] reported that brain-based learning approach is an effective instrument for increasing students' motivation. In comparing the pretest and posttest mean achievement scores on students' motivation, it was observed that there was a significant difference between the experimental and control in favour of the experimental group that used BBL. It was observed that the brain-based learning activities had a statistically significant influence on the students' motivation. Therefore, it can be concluded that brain-based learning activities improve students' motivation. Similarly, Materna [57] and Yıldırım [55] observed that the students in the experimental group, that had their lessons in accordance with Brain-based learning, were more motivated than the ones in the control group that used Lecture-based teaching method. But, this contradicts the views of Weiner [58] that observed that not all Brain-based motivation is positive since it depends on a learner's perspective one student may failed a test and may be motivated to study harder whereas another student may fail the same test and give up.

The findings related to the mean retention scores of students in the experimental and control groups on their knowledge retention in Electrochemistry lesson was shown in Table 6. The results showed that the experimental group which had engaged in Brain-based learning produced a higher overall improvement in scores on the Electrochemistry delayed retention test scores used to determine students' knowledge retention or more retentive learning than the control group that used lecture-based teaching approach. The findings of this study imply that Brain-based learning had much more effect on students' learning and retention compared to Lectured-based teaching which is supported by works of previous researchers [40,8,41,42 & 43].

The findings therefore revealed that there were positive mean gains in Brain-based learning since the Electrochemistry lessons were taught in compliance with the working principles of the brain, and positive contributions were made on students' motivation, attitudes, and academic achievement [59,60,61,6,10,28 & 5]. In addition to these results, it was determined that a statistically significant difference in the retention test scores of experimental and control group in favour of the experimental group. This showed that the experimental group that used Brain-based learning provided realization of knowledge retention for Electrochemistry that the Lecture-based strategy that was teacher-centred and learnt concepts in Electrochemistry through memorization since they were not engaged in practical activities themselves. As seen from the results of the study, in the control groups, there was no statistically significant difference between the scores of the students in the pre-test and post-test on students' academic achievement, attitude, motivation and knowledge retention. This was because the activities implemented were not effective enough influencing significant changes and increasing students' attitude and motivations towards chemistry and influencing more positive academic achievement and knowledge retention in students.

5. CONCLUSIONS

This study explored the effectiveness of brain based learning on students' academic achievement, attitudes, motivation and knowledge retention in Electrochemistry. With the information gathered through quantitative analysis, this study confirms that Brain-based learning have significant effect on students' academic achievement tests. Therefore, it can be concluded that Experimental group who were taught Electrochemistry using Brain-based learning had a better achievement and retention. It can be concluded also that brain-based learning activities improved students' attitudes and motivation towards chemistry. This clearly explains that when learners are taught with meaningful and active practical activities in a thematic way with appropriate innovative learning in a critical thinking and problem solving skills they feel more comfortable, self-confident and motivated in the classroom, which may in turn help them to gain success in achievement and retention. This indicated why measures that teachers can employ such as BBL could enhance achievement, attitudes, motivations and knowledge retention of learners such as integrating other brain-based activities that could be considered as a valuable and effective teaching tool. The findings of this study imply that Brain-based learning (BBL) had much more positive effect on students' academic achievement, attitude, motivation and knowledge retention in Electrochemistry compared to Lecture-based teaching.

6. EDUCATIONAL IMPLICATIONS

i. The effectiveness of Brain-based learning strategy helped in the development of positive attitude, high motivations and reduced difficulty levels of chemistry students by improving their knowledge retention through problem solving and thinking skills like critical thinking, decision-making and creative thinking.
ii. The provision of enriched learning environment, well-designed brain-compatible instructional materials and judicious use of varied strategies in Brain-based learning would help in reducing the fear and undesirable attitude and motivation amongst students taught chemistry concepts.
iii. The brain-based learning strategy on student achievement in the Electrochemistry class was associated with

opportunity for relax alertness learning environment which eliminated fears in the learner, while maintaining a highly challenging learning environment.

iv. A brain compatible teacher teaches with the brain in mind and uses effectively the principles and strategies in a purposeful way; so science educators should be constantly updated through continuous professional development such as workshops.

v. Evidence from research suggests that stress has a significant influence on students' creativity, memory, behavior and learning. Teachers can create a science classroom friendly environment to decrease stress in students' through positive strategies such as incorporating recess, teaching coping skills and integrating stretching exercises used in BBL.

vi. Brain-based learning strategy could also provide insight for educators, curriculum or syllabus designers, material developers and course book designers since it enhances students' achievement, attitude, motivation and knowledge retention.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Olaoluwa SA, Ayantoye CA. Impact of brain-based instructional strategy on academic performance of deaf students in mathematics in Oyo School of Handicapped, Nigeria. World Journal of Educational Research. 2016;3(2):447-459.
2. Lucas RW. The creative training idea book: Inspired tips and techniques for engaging an effective learning. New York: AMACOM; 2004.
3. Sousa DA. The ramifications of brain research. School Administrator Web Edition; 2004.
4. Caine RN, Caine G. Making connections: Teaching and the human brain. New York: Addison-Wesley; 1994.
5. Jensen EP. Brain-based learning: The new paradigm of teaching (2th ed). San Diego, CA: Corwin Press; 2008.
6. Zull JE. The art of changing the brain: Enriching teaching by exploring the biology of learning. Sterling, VA: Stylus; 2002.
7. Kolb AY, Kolb DA. Learning styles and learning spaces: Enhancing learning in higher education. Academy of Management Learning and Education. 2005;4(2);193-212.
8. Duman B. The effects of brain-based learning on the academic achievement of students with different learning styles educational sciences. Theory & Practice. 2010;10(4):2077-2103.
9. Tileston D. 10 best teaching practices: How brain research, learning styles and standards define teaching competencies (2th ed). Thousand Oaks, California: Corwin Press; 2005.
10. Zadina JN. Brain research-based effective strategies to enhance learning and energize instruction. Paper presented at the meeting of the U.S. Department of Education Office of English Language Acquisition Summit Conference. U.S.A; 2004.
11. Ryan T, Abbott J. Constructing knowledge and shaping brains. HOW Journal. 2001; 9(1):9-13.
12. Caine RN, Caine G. Unleashing the power of perceptional change: The potential of brain-based teaching. Alexandria, VA: Association for Supervision and Curriculum Development; 1997.
13. Jensen E. Teaching with the brain in mind. Alexandria, VA: The Association for Supervision and Curriculum Development; 1998.
14. Schibeci RA. Selecting appropriate attitudinal objectives for school science. Science Education. 1983;67(5):595-603.
15. Kocabaş A. Reliability and validity or the attitude scale towards music for stage two of basic education students. Journal of Hacettepe University Faculty of Education. 1997;13:141-145.
16. Jack GU. Analysis of Senior secondary school students' experienced difficulty in science process skills acquisition in chemistry. Unpublished PhD Thesis, DELSU, Abraka; 2013.
17. Martin R, Sexton C, Wanger K, Gerlovich J. Science for all children. USA: Allyn and Bacon; 1998.
18. Wolters CA, Rosenthal H. The relation between students' motivational beliefs and their use of motivational regulation strategies. International Journal of Educational Research. 2000;33:801-820.
19. Özçelik DA. Education programs and teaching. Ankara: OSYM Publishes; 1992.

20. Tuan CS. The development of a questionnaire to measure students' motivation towards science learning. International Journal of Science Education. 2005;27(6):634-659.
21. Federal Republic of Nigeria (FRN). National Policy on Education (4th edition). Lagos: NERDC Press; 2013.
22. Remadevi K. Application of brain based learning in teaching chemistry at secondary level. A minor research project (education). 2014;9-15. Available:http://www.nsstcpdlm.org/pdf/dr.%20k-remadevi-minor-project.pdf (Retrieved on 30/04/2017)
23. Jenson E. Moving with the brain in mind. Educational Leadership. 2000;5(3):34-38.
24. Opateye JA. Developing diagnostic adaptive testing skills to improve teaching and learning of senior secondary school electrochemistry. Journal of Science Teachers Association of Nigeria 50th Annual Conference Proceedings; 2009: 150.
25. Bauer CF. Attitude toward chemistry: A semantic differential instrument for assessing curriculum impacts. Journal of Chemical Education. 2008;85:1440-1445. Available:http://dx.doi.org/10.1021/ed085p1440.
26. Caine G, Caine RN, McClintic C, Klimek K. 12 Brain/mind learning principles in action. Thousand Oaks, CA: Orwin Press; 2005.
27. Jensen E, Dabney M. Learning smarter. San Diego: The Brain Store; 2000.
28. Sousa D. How the brain learns (2nd Ed). Thousand Oaks, California: Corwin Press; 2006.
29. Caine RN. Building the bridge from research to classroom. Educational Leadership. 2000;58(3):59-65.
30. Caulfield J, Kidd S, Kocher T. Brain-based instruction in action. Educational Leadership. 2000;58(3):62-65.
31. Wagmeister J, Shifrin B. Thinking differently, learning differently. Educational Leadership. 2000;58(3):45-48.
32. Worthock JMM. Brain based learning principles applied to the teaching of basic cardiac code to associate degree nursing students using the human patient simulator. Unpublished doctoral dissertation, University of South Florida. St. Petersburg; 2002.
33. Bowman JB. Satisfaction with and preference for on-line learning: An investigation of the impact of social and emotional learning strategies. Unpublished doctoral dissertation, Pennsylvania State University, Pennsylvania; 2003.
34. Erlauer L. The brain-compatible classroom: Using what we know about learning to improve teaching. Alexandria, VA: ASCD; 2003.
35. Getz CM. Application of brain-based learning theory for community college developmental English students: A case study. Unpublished doctoral dissertation, Colorado State University; 2003.
36. Brodnax RM. Brain compatible teaching for learning. Unpublished doctoral dissertation, Indiana University, Indiana; 2004.
37. Jeffrey JM. Brain-based learning and industrial technology education practice: Implications for consideration. Unpublished doctoral dissertation, Central Michigan University; 2004.
38. Cengelci T. The effects of brain-based learning to success and retention in social studies. Unpublished master's thesis, Anadolu University, Institution of Educational Sciences, Eskisehir; 2005.
39. Duman B. The effect of brain-based instruction to improve on students' academic achievement in social studies instruction. Paper presented at the meeting of the ICEE 2006 9th International Conference on Engineering Education, San Diego, CA; October, 2006.
40. Ozden M, Gulteki M. The effects of brain-based learning on academic achievement and retention of knowledge in science course. Electronic Journal of Science Education. 2008;12(1):1-17.
41. Akyürek E, Afacan O. Effects of brain-based learning approach on students' motivation and attitudes levels in science class. Mevlana International Journal of Education (MIJE). 2013;3(1):104-119.
42. Haghighi M. The effect of brain- based learning on Iranian EFL achievement and retention. Procedia - Social and Behavioral Sciences. 2013;70:508 – 516.
43. Mahnaz AT, Mahbobeh SK. The effects of brain-based training on the learning and retention of life skills in adolescents. International Journal of Behaviourial Sciences. 2016;10(4):140-144.
44. Bayındır H. An investigation of students' attitudes towards brain- based applications in English composition skills II course: A case study. Unpublished master thesis,

Middle East Technical University, Ankara; 2003.
45. Tüfekçi S. Brain-Based learning access, retention, attitude and learning process effect. Unpublished Doctoral Dissertation, Hacettepe University, Ankara; 2005.
46. Avcı DE. The effect of brain based learning approach to achievement, attitude and retention of knowledge in 7th grade students' science classes of elementary school. Unpublished Doctoral Dissertation, Gazi University, Ankara; 2007.
47. Çelebi K. The effect of brain based learning on students' achievement and attitude. Unpublished master thesis, Selçuk University, Konya; 2008.
48. Baş G. Effects of brain-based learning on students' achievement levels and attitudes towards English lesson. Elementary Education Online. 2010;9(2):488-507.
49. Baştuğ M, Korkmaz İ. Applying strategies of brain based learning on the teaching social studies at the fifth grade. Journal of Selçuk University Ahmet Keleşoğlu Education Faculty. 2010;29:407-421.
50. İnci N. Brain-Based learning of science and technology achievement, attitude, and the effect of remembrance. Unpublished master thesis, Fırat University, Elazığ; 2010.
51. Yücel C. According to brain-based learning approach to teaching science and technology impact on academic achievement and attitude. Unpublished Masters' thesis, Osmangazi University, Eskişehir; 2011.
52. Adebayo FO. Brain-based instructional strategy and students' learning outcomes in chemistry in Ibadan, Nigeria. Unpublished master's thesis, University of Ibadan, Ibadan, Nigeria; 2005.
53. Aydın S. Brain-Based learning theory-based impact on biology education academic achievement and attitude. Unpublished master thesis, Gazi University, Ankara; 2008.
54. Samur Y. Brain-based learning (e-learning) 7th grade students of elementary school English courses effect on academic achievement and attitudes towards the course. Unpublished master thesis, Muğla University, Muğla; 2009.
55. Yıldırım Ö. The effect of brain based learning achievement, attitude and motivation. Unpublished master thesis, Zonguldak Karaelmas University, Zonguldak; 2010.
56. Salmiza S. The effectiveness of the brain-based teaching approach in generating students' learning motivation towards the subject of physics: A qualitative approach. US-China Education Review A. 2011;(1): 63-72.
57. Materna L. Impact of concept-mapping upon meaningful learn and metacognition among foundation level associate degree nursing students. Unpublished Doctoral Dissertation, Capella University, Chicago; 2010.
58. Weiner B. The development of an attribution-based theory of motivation: A history of ideas. Education Psychology. 2010;45:28–36.
59. Kotulak D. Recognition memory, circadian rhythms, and sleep. Perceptual Motor Skills. 1997;85(1):99-104.
60. Godwin M. Who are you? 101 ways of seeing yourself. New York: Penguin Books; 2000.
61. Wolfe P. Brain matters: Translating research into classroom practice. Alexandria, Virginia: Association for Supervision and Curriculum Development; 2002.

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