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EFFECT OF BRAIN-BASED STRATEGY ON SENIOR SECONDARY SCHOOL STUDENTS' PERFORMANCE IN MATHEMATICS IN EKITI STATE

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ABSTRACT: *The study examined the effect of brain-based strategy on senior secondary school students' performance in Mathematics in Ekiti State. The study adopted the quasi-experimental of pre-test, post-test design. The population for the study consisted of all the Senior Secondary School three (S.S.S. II) students in all public Secondary Schools in Ekiti State, Nigeria. The sample consisted of 181 S.S.S. II found in intact classes of the four schools that were selected for the study through multistage sampling procedure. Mathematical Based Performance Test (MBPT) was used to collect the needed data for this study. The instrument consisted of 50 items to examine the performance of students in Mathematics. The experimental procedure for the study was in three stages: the pre-treatment stage (one week), the treatment stage (ten weeks) and the post-treatment stage (one week). The data collected were analysed using descriptive and inferential statistics. It was revealed that brain-based strategy was more effective and reliable than the conventional method. It was recommended among others that brain-based strategy should be adopted as a means of instruction during Mathematics class. This will enable Mathematics teachers to pay more attention to individual students in teaching-learning process.*

KEYWORDS: brain-based, performance, students, mathematics

INTRODUCTION

Mathematics is a subject seen by the nation as the basis of scientific and technological knowledge that is important to the socio-economic development of a nation. Olofin (2019) in his opinion sees Mathematics as the science that studies and clarifies quantities, numbers, measurements, and the connections between them. According to Olofin and Falebita (2020), Mathematics can be described as an instrument for the development of any science-based discipline such as graphics, technology, astronomy, analytical reasoning and industry. Hence, its significance cannot be underrated in human endeavours. According to Popoola and Olofin

(2020), Mathematics is one of the central and indispensable subjects at primary and secondary school levels of education because of its necessity and usefulness in everyday activities and it is understood as the access to future professions in diverse fields. That is why in developed and developing countries of the world, Mathematics is identified as the subject that must be taught at all levels of education.

Despite the significance of Mathematics, many students are still not well grounded in the subject. Evidence from examiner's report have revealed that the students' performance in their West African School Certificate Examination especially in Ekiti State have been inconsistent between 62% and 88%. Table 1 shows the percentage distributions at credit pass and above of students who sat for Senior School Certificate Examination (SSCE) in Mathematics conducted by WAEC from 2015 – 2020 in Ekiti State. The table shows a wavering performance of students in the subject. Available statistics from Table 1 shows that the percentage of students who passed Mathematics at credit level and above was less than 62% in 2015. The performance improved a tad in 2016 and 2017 to 69% and 90% respectively, but declined to 87% in 2018, 82% in 2019 and 62% in 2020.

Table 1: Students' Performance in Mathematics in May/June Senior School Certificate Examinations (SSCE) 2015-2020

Year	**Number Registered**			**A1-B3**				**C4 – C6**				**D7 – E8**				**F9**			
	M	**F**	**Total**	**M**	**F**	**Total**		**M**	**F**	**Total**		**M**	**F**	**Total**		**M**	**F**	**Total**	
2015	6898	6787	13685	1079	990	2069	15	3353	3114	6467	47	1673	1611	3284	24	793	1072	1865	14
2016	5831	5520	11351	1303	1128	2431	21	2781	2668	5449	48	1265	1296	2561	23	482	428	910	8
2017	5852	5808	11660	3327	3560	6887	59	1948	1709	3657	31	248	231	479	4	329	308	637	5
2018	5506	5467	10973	2658	2651	5309	48	2289	2021	4310	39	282	358	640	6	277	437	714	7
2019	5664	5736	11400	3271	3163	6434	56	1505	1414	2919	26	360	511	871	8	528	648	1176	10
2020	7008	7499	14507	1702	1634	3336	23	2814	2844	5658	39	1105	1216	2321	16	1387	1805	3192	22

Source: Ekiti State Ministry of Education, (2021)

Olofin and Falebita (2020) discovered that the cause of the low Mathematics performance of most learners could be that they were not taught with suitable strategies, they cannot self-regulate the study strategies, and do not understand how to apply these strategies while teaching the students. In view of the limited studies, the researchers considers it important to seek for the efficiencies of brain-based strategy on students' performance in Mathematics and also to contribute to the findings on the influence of gender on students' performance in Mathematics. Brain-Based Learning instructional strategy is a learner-centered and teacher-facilitated strategy that uses learners' cognitive endowments. This instructional strategy is hinged on the structure and purposes of the brain in different aspects such as learning, assimilating, thinking and remembering. Brain-Based Learning is described as any teaching strategy that uses information about the human brain to arrange how lessons are built and facilitated with emphasis rested on how the brain learns naturally. It is a method for building creative solutions to problems. It is an open sharing session which motivates all students to participate. Brain-

Based Learning involves accepting the rules of how the brain processes, and then organizes instruction putting in mind these rules to achieve meaningful learning (Duman, 2010).

The Brain-Based Approach shows how teachers can establish environments for active learning, taking into cognisance how the brain learns, which is important for students' learning. Learning, in brain, is a process which begins with the sensory memory receiving incoming information. The information is first sent to the thalamus. Then, it is either sent to the cortex for analysis and response, or sent to amygdala (short-term memory) for scanning and storing in the memory. Then the information is sent to hippocampus (long-term memory). In order for information to be transferred from the short-term memory to the long-term memory, strategies such as repetition should be used (Jack & Kyado, 2017). Since learning occurs in the brain in this way, learning milieu should be intended in line with the brain-based learning principles.
Caine and Caine (2002) define brain-based learning as recognition of the brain's codes for a meaningful learning and modifying the teaching process in relation to those codes. The principles of brain-based learning suggest that effective learning could occur only via practicing real life experiences. Learning becomes more communicative when the brain aids the processes in search of meaning and patterning. Accordingly, it helps the learners to internalize and personalize learning experiences. Therefore, it is significant that learners be motivated to partake in the teaching and learning process vigorously and that teaching materials be selected in respect to their learning preferences.

Brain-based learning developed from three collaborating fields of study: cognitive neuroscience, cognitive psychology, and education. It is sometimes known as mind, brain and education science, cognitive neuroscience, developmental neuroscience, and social or affective neuroscience or neuro-education (Dubinsky, et al., 2013). The aim of brain-based learning is to support teaching and learning with how the human brain is naturally arranged for learning (Tokuhama-Espinosa, 2011).

Brain-Based Learning focuses on how the brain works to learn efficaciously. It is important for teachers to comprehend how the brain works when learning. It is only after comprehending its way of functioning, that teachers are able to select the most appropriate strategy to teach their students. Brain-Based Learning is an approach that encircles the stimulation of the brain, body, and spirit as an entity, and not as different elements in learning. Actually, according to Samur, Tech, and Duman (2011), there is a connection between mind and body. The senses are in charge of complementing what occurs in the brain because this organ "only perceives the stimuli to which we give attention.

Despite many researches (Ozden & Gultekin, 2008; Saleh, 2011; Seyihoglu & Kaptan, 2012; Duman, 2014) carried out in looking at the effect of brain-based strategy, it was observed by the researchers that it seems there is a dearth in literature on the effect of brain-based strategy in connection with gender on the performance of students in Mathematics. In view of this, the study examined the effect of brain-based strategy on senior secondary school students' performance in Mathematics in Ekiti State. The specific objectives of the study were to:

1. examine the performance of students in Mathematics before and after treatment

2. examine the difference in the pre-test and post-test mean scores of students in the experimental and control groups;
3. determine the interactive effect of treatment and gender on students' performance in Mathematics

Research Question

This research question was raised for the study:

1. What is the performance of students in Mathematics before and after treatment?

Research Hypotheses

The following null-hypotheses were formulated to guide the study:

1. There is no significant difference in the pre-test mean scores of students in Mathematics in the experimental and control groups.
2. There is no significant difference in the post-test mean scores of students in Mathematics in the experimental and control groups.
3. There is no significant difference in the pre-test and post-test mean scores of students in the experimental and control groups.
4. There is no significant interactive effect of treatment and gender on students' performance in Mathematics

LITERATURE REVIEW

There are three main elements of brain-based learning that come out of the work of Caine and Caine: relaxed alertness, orchestrated immersion, and active processing. Relaxed alertness is a term used regarding student emotion during learning. All learning has an emotional impact on students. That impact can be positive or negative depending on the circumstances surrounding learning and the students. They suggested that teachers create learning experiences that are high in challenge but low in threat to facilitate a positive learning experience. For students to engage in long periods of uncertainty when grappling with new learning concepts, students need to feel safe and secure, so they are willing to take risks. Learning happens when students are pushed beyond their comfort zone but feel safe enough to engage in the challenge presented (Zadina, 2015).

Orchestrated immersion is a term that refers to the global processing of new information. Caine and Caine in Zadina (2015) referred to orchestrated immersion as a teacher's ability to take information from the page and bring it to life. The focus of orchestrated immersion is creating a learning experience where students are almost overwhelmed with information so that they are forced to engage the local memory system in their exploration of the content. These learning environments contain a mix of predictable and unpredictable elements that are challenging, meaningful, and coherent for the brain.

Active processing is a term that is used to describe the act of making meaning of the learning experience. Gearin and Fien (2016) defined this as the act of processing the learning experience. When students are engaged in active processing, they are reflecting, looking for patterns, comparing what they know to what they see or hear and making connections. They described it as the consolidation and internalization of information that is both meaningful and coherent. It is the path to understanding, not just memory.

Another principle of brain-based learning is the mind-body connection. In addition to increased attitudes, motivation, and academic achievement, studies also demonstrated that physical education and movement throughout the day can enhance learning (Gearin & Fien, 2016; Stevens-Smith, 2016). Stevens-Smith (2016) refers to this as the physical learning system. He suggests that the physical learning system likes challenging academic tasks and needs to be actively engaged in the learning process. Gearin and Fien (2016) also connects biology and neurology suggesting that exercise not only enhances circulation, but also has been shown to spur the production of nerve growth as well as release dopamine which helps regulate emotions. Therefore, movement throughout the school day can enhance learning and potentially increase academic achievement.

Caine and Caine in Huen and Chan (2010) emphasized that in order to identify essential general aspects of how a person learns, it is necessary to perceive the brain, mind, and body as a unit, which can be understood through the twelve Brain-Based principles. The twelve principles comprise the Brain-Based Approach and facilitate brain stimulation through the integration of mind and body. In other words, these principles are based on the idea that brain, body, and spirit have to work together when learning a foreign language. The twelve principles are listed as follows:

1. All learning engages the physiology;
2. The mind is social;
3. The search for meaning is innate;
4. The search for meaning occurs through patterning;
5. Emotions are critical to patterning;
6. The brain processes parts and wholes simultaneously;
7. Learning involves both focused attention and peripheral perception;
8. Learning is both conscious and unconscious;
9. There are at least two approaches to memory;
10. Learning is developmental;
11. Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and/or fatigue; and
12. Each brain is uniquely organized.

The Brain-Based Learning Approach then holds that body, mind, and spirit are entailed when learning.

1. Principle 1 (All learning engages the physiology): Taking into account all the physical senses gives students a global experience when learning. As said by Caine, Caine, McClintic, and Klimek (2009), all students learn more effectively when involved in experiences that naturally call on the use of their senses, action, movement, and decision making.
2. Principle 2 (The mind is social): Human beings have a need to relate to others in order to give and receive love, care, and empathy. Naturally, people influence each other with their behaviors and beliefs. Social interaction is a way to engage students, create communication, and take risks. Huen and Chan (2010) recommended arranging frequent pair-and-share activities, or grouping work to foster students to work more cooperatively and learn from each other; thus, these activities empower students to face challenges in the personal and academic field since this connection brings confidence and motivation.

3. Principle 3: The search for meaning is innate. Meaningfulness enhances relaxed alertness and relaxed alertness is when the brain has an optimal state for learning. The optimal state for learning is allowed when one finds purpose, understands, and is able to connect to what is being studied. To achieve what is being said, students have to relate the subject to their own life, knowledge, and interests. They need to experience a connection between the new ideas and the former knowledge. Understanding occurs when new information is synthesized and mastered, that is what teachers attempt.
4. Principle 4 (The search for meaning occurs through patterning): Patterning and learning are connected. As stated by Caine, Caine, McClintic, and Klimek (2009), all human beings are driven by a need to identify, name, and organize the configuration of elements (or patterns) that make up their known world; thus, the brain perceives and organizes information. Patterns are a particular way in which something is done, is organized, or happens (Pattern, 2016). Patterns vary, depending on the learner, and they allow people to make sense of new subjects.
5. Principle 5 (Emotions are critical to patterning): Emotions affect choices, reactions, and feelings. The brain is driven by emotions, which can be positive or negative. Emotions are opportunities for learning, and the teacher can direct them toward the desired aim by inviting students to control their own learning, allowing them to have the opportunity to struggle, and encouraging them to develop their abilities. One role of the teacher is to engage students in the learning process by providing them with an optimal environment that would enhance learning.
6. Principle 6. (The brain processes parts and wholes simultaneously): Language can be seen as a puzzle; one piece does not make sense by itself, but the pieces together show a whole that can be appreciated and understood. Caine, et al (2009) stated that making sense of experience requires both a big picture and paying attention to the individual parts. Teaching needs to begin with an experience for students that provide exposure to the overall nature of the subject; this experience of the whole is necessary in order to show learners what they can achieve. However, the parts lead students to understand significant information that covers the gaps in knowledge. Therefore, both the whole and details must be intertwined to learn more effectively.
7. Principle 7 (Learning involves both focused attention and peripheral perception): Paying attention to new information on purpose is critical to memory, but the context that surrounds learners also provides information for learning, even if attention is not intended. Thus, leading students' attention to specific data allows them to understand new information since they are making an effort to center their attention on a focal point or amount of information, and they know it
8. Principle 8 (Learning is both conscious and unconscious): Some goals of learning are to acquire new information unconsciously and to be able to master it consciously. These processes might be deliberate or involuntary. Teachers and learners can make unconscious learning become something conscious; that means that students would not only learn but also understand what and how they learn; that is called metacognition. For metacognition or conscious learning to occur, students need time to reflect on their own learning. Moreover, as established by Caine, et al (2009), making learning conscious is the ability to observe one's performance in order to evaluate what is occurring during the process. One strategy that teachers might implement to advocate conscious learning is to provide learners with opportunities to express new perceptions that they have acquired. Questioning also helps students to reflect on their own learning.

9. Principle 9 (There are at least two approaches to memory): The first approach is archiving or memorizing isolated facts, skills, and procedures, and the other approach is engaging multiple memory systems in order to make sense of experience. Storing (archiving) is a traditional approach to learning in which teachers provide learners with information that must be remembered. However, the second approach, engaging multiple memory systems, refers to the commitment to teaching students how to learn by using different means so that they make sense of experience. Memorization is explicit; it does not mean that it is incorrect, but if it is combined with making sense of what is being learned, it is easier to remember new information.

10. Principle 10 (Learning is developmental): Teachers play an important role in helping students develop their full capacities and interest toward the class subject beyond the classroom. Thus, teachers need to be concerned about students' previous knowledge and performance since this provides them with a framework to start building new knowledge. Learning is an ongoing process that does not stop in the classroom, but continues in other contexts to which the learner is exposed. Students make choices that correspond to their individual characteristics and preferences. These choices guide them to understand the class content in different ways. Caine, et al (2009) believe that learning is more effective when the individual is seen as unique in the developmental process. This means that learners are individuals capable of taking part in decisions concerning their own learning stage.

11. Principle 11 (Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and/or fatigue): According to this principle, students learn better if the conditions and environment they are exposed to during the learning process trigger relaxation. Actually, Polka and McKenna (2016) pointed at the fact that all students can learn more effectively in a supportive, empowering, and challenging environment. Hence, when learners face stress, their attention, competence, and confidence are affected since they are focused on the factors that might be disturbing them. This does not mean that teachers cannot encourage challenges; actually, challenging students is positive since it would make them step forward and leave their comfort zone. Nevertheless, teachers should find and implement techniques that challenge students without making them feel threatened.

12. Principle 12 (Each brain is uniquely organized). Einstein (as cited in Polka & McKenna, 2016) said that "everybody is a genius, but if you judge a fish by its ability to climb a tree, it will live its whole life believing it is stupid; unfortunately, this happens when students' individual characteristics are not taken into account. Students need to know that they learn differently and are not required to be good at the same abilities to be successful. According to this principle, Caine, et al (2009) established that students learn more efficiently when their individual talents, abilities, and capabilities are involved. Although the learning process usually takes place in groups of students, teachers need to do research on learning styles, multiple intelligences, and personality styles so that all students attain their learning goals. Each brain is unique; not everyone has the same talents or is equally proficient in the same intelligences. Therefore, teachers who implement different techniques and respect individual differences allow all students to have access to learning.

The application of brain-based learning strategies in classrooms has social-emotional as well as academic benefits. Studies such as the one conducted by Akyurek and Afacan (2013) proved to increase student attitudes and motivation toward the subject when brain-based learning strategies were incorporated into typical classroom instruction. This finding was consistent with studies that were conducted with younger students (Samur & Duman, 2011) as well as older students (Saleh, 2011; Shabatat & Al-Tarawneh, 2016). Duman (2010) found that students in test groups that received instruction using brain-based learning strategies demonstrated a significant increase in academic achievement compared to students in control groups who received more traditional instruction. These findings were confirmed in similar studies conducted with adult learners (Dubinsky, Roehrig & Varma, 2013).

Saleh (2011) included 100 students in the quasi-experimental study, with 50 in the experimental group and 50 in the control group. Students were randomly selected from four different schools to participate in the study. The experimental group was given instruction using a brain-based teaching approach and the control group followed a more conventional method. Before the intervention, both groups obtained almost equivalent physics learning motivation mean scores on the Likert scale pretest, with the control group receiving a 2.13 mean score and the test group receiving a 2.15 mean score. After the intervention, the experimental group obtained a mean score on the same Likert scale of 2.82, representing a gain of 0.67, while the control group received a score of 2.41 representing a gain of 0.28. Findings indicated that the experimental group had gains in performance that were considered statistically significant ($p < 0.05$) and approximately twice those of the control group, causing Saleh (2011) to conclude that a brain-based teaching approach could significantly impact student performance and attitude toward learning challenging science content. A similar study was conducted by Akyurek and Afacan (2013) with eighth grade students in Turkey during a complex science unit regarding cell division and heredity. Like Saleh (2011), Akyurek and Afacan questioned if students who received instruction using a brain-based learning approach would have increased motivation and improved attitudes toward the complex subject. Student attitude data were collected using an attitude and motivation questionnaire. They used a Likert-type scale to measure student attitudes and motivation before and after the study as pre-test, post-test analysis of the data. Students were divided into three groups, two control and one test group, using a research model from true experimental design. Students were separated by equalization to ensure validity and objectivity. Results corroborated Saleh's (2011) findings demonstrating a statistically significant influence on both students' attitude toward the science content and increased student performance in the test group compared to students in the control group.

In studies conducted to determine the effect of brain-based learning on academic achievement, researchers anecdotally observed students engaging more actively in the lessons (Duman, 2010) as well as developing more positive attitudes toward the content (Shabatat & Al-Tarawneh, 2016). Some scholars indicated statistically significant results ($p < 0.05$) in the increase of academic achievement of students in experimental groups receiving brain-based instruction regardless of student age, gender, or content (Saleh, 2011; Samur & Duman, 2011; Shabatat & Al-Tarawneh, 2016).

Using the qualitative strategy of a case study, Yagcioglu (2014) examined the effect of a brain-based learning approach on university level students learning English as a second language, and found that students who learned English using a brain-based approach were more interested during class and enjoyed classes more than students who learned in a more traditional manner.

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While the student populations, sample sizes and methods of these studies differed, the results were similar.

METHODOLOGY

The study adopted the quasi-experimental of pre-test, post-test design. The population for the study consisted of all the Senior Secondary School three (S.S.S. II) students in all public Secondary Schools in Ekiti State, Nigeria. The sample consisted of 181 S.S.S. II found in intact classes of the four schools that were selected for the study. The sample were selected using multistage sampling procedure which involved four stages of selection.

Mathematical Based Performance Test (MBPT) was used to collect the needed data for this study. The instrument consisted of 50 items to examine the performance of students in Mathematics. The reliability of the instrument was established through a field testing which involved 30 senior secondary school students who were not part of the study. The internal consistency of the instrument was then ascertained using the split half method. The scores obtained were split into two equal halves. This yielded a reliability coefficient of 0.81 for the half length of the test. The coefficient obtained was later converted to a full length using Spearman Brown Prophecy formula, and a reliability coefficient of 0.89 was obtained, which was considered high enough and reliable for the research.

The experimental procedure for the study was in three stages: the pre-treatment stage (one week), the treatment stage (ten weeks) and the post-treatment stage (one week). Twelve weeks were used altogether for the whole exercise. The data collected were analysed using descriptive and inferential statistics. The research questions raised were answered using descriptive statistics involving frequency counts, mean, standard deviation and percentages while the hypotheses postulated were tested using inferential statistics involving t-test and Univariate Analysis of Variance (two-way). Decisions were taken at 0.05 level of significance.

RESULT

Research Question 1: What is the performance of students in Mathematics before and after treatment?

In answering the question, mean scores of students in Mathematics before and after being exposed to treatments were computed and compared. The result is presented in Table 1.

Table 1: Mean and standard deviation of pre-test and post-test scores of students in the experimental and control groups

Strategies	Test	N	Mean	S.D	Mean Diff.
Experimental	Pre Test	89	49.17	10.11	**34.78**
	Post Test		83.95	6.71	
Control	Pre Test	92	49.13	11.19	**11.68**
	Post Test		60.81	10.18	
Total		**181**			

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Table 1 revealed the performance of students in Mathematics before and after treatment. The performance of students between pre-test and post-test scores for experimental group is 34.78 while control group is 11.68. The graphical representation below further shows the more effective strategy in the teaching of Mathematics.

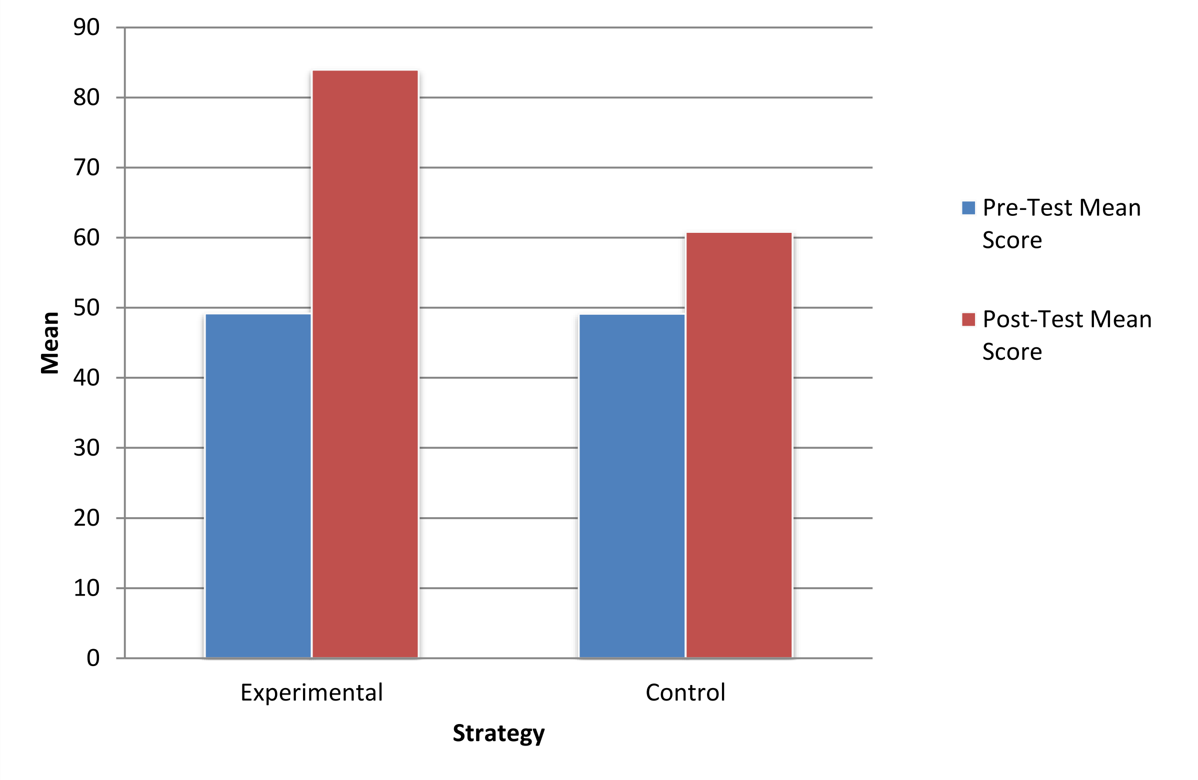

Figure i: Bar chart showing pre-test and post-test mean scores of students in Mathematics in the experimental and control groups

Test of Hypotheses

H₀1: There is no significant difference in the pre-test mean scores of students in Mathematics in the experimental and control groups.

In order to test the hypothesis, performance of students before treatment were collected from Mathematical Based Performance Test (MBPT). T-test was used to compute difference in performance before treatment. The result is presented in Table 2.

Table 2: t-test Analysis for difference in the pre-test mean scores of students in Mathematics in the experimental and control groups

Variations	N	Mean	SD	Df	t_{cal}	P
Experimental	89	49.17	10.11	179	0.024	0.939
Control	92	49.13	11.19			

P>0.05

Table 2 shows that the t-cal value of 0.024 was not significant because the P value of 0.939 was greater than 0.05significant point. This implies that null hypothesis is not rejected. Therefore, there is no significant difference in the pre-test mean scores of students in Mathematics in the experimental and control groups. The implication of this finding is that the

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students in the experimental and control groups were homogeneous at the commencement of the study.

H_o2: There is no significant difference in the post-test mean scores of students in Mathematics in the experimental and control groups.

In order to test the hypothesis, performance of students after treatment were collected from Mathematical Based Performance Test (MBPT). T-test was used to compute difference in performance before treatment. The result is presented in Table 3.

Table 3: t-test Analysis for difference in the post-test mean scores of students in Mathematics in the experimental and control groups

Variations	N	Mean	SD	Df	t_{cal}	P
Experimental	89	83.95	6.71	179	18.112*	0.000
Control	92	60.81	10.18			

*P<0.05

Table 3 shows that the t-cal value of 18.112 was significant because the P value of 0.000 was less than 0.05significant point. This implies that null hypothesis is rejected. Therefore, there is significant difference in the post-test mean scores of students in Mathematics in the experimental and control groups.

H_o3: There is no significant difference in the pre-test and post-test mean scores of students in the experimental and control groups. In order to test the hypothesis, performance of students before and after treatment were collected from Mathematical Based Performance Test (MBPT). Analysis of Covariance was used to compute difference in performance before and after treatment in the groups. The result is presented in Table 4.

Table 4: Analysis of Covariance for difference in the pre-test and post-test mean scores of students in Mathematics in the groups

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4094.604[a]	2	2047.302	292.388	.000
Intercept	1523.925	1	1523.925	217.641	.000
Pre-Test	13.821	1	13.821	1.974	.548
Groups	2651.676	1	2651.676	378.703*	.000
Error	1246.320	178	7.002		
Total	369439.111	181			
Corrected Total	5340.924	180			

a. R Squared = .881 (Adjusted R Squared = .876)

The result presented in table 4 shows that there is a significant difference in the pre-test and post-test mean scores of students in the experimental and control groups as F_{cal} = 378.703, P= 0.000<0.05. This result led to the rejection of the null hypothesis. By implication, there is significant difference in the pre-test and post-test mean scores of students in the experimental and control groups. In order to find out the more probable effective strategy, Multiple Classification Analysis (MCA) was carried out. The result is shown in Table 5.

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Table 5: Multiple Classification Analysis (MCA) of students' performance in Mathematics by treatment

Grand Mean = 71.19					
Variable + Category	N	Unadjusted Dev'n	Eta^2	Adjusted for Independent + Covariate	Beta
Experimental	89	12.76	.83	12.69	.52
Control	92	-10.38		-10.46	
Multiple R					.939
Multiple R^2					.881

The result in Table 5 shows the Multiple Classification Analysis (MCA) of students' performance in Mathematics by treatment. It reveals that, with a grand mean of 71.19, students in the experimental group had higher adjusted mean score of 83.95(71.19+12.76) than their counterparts in the control group 60.81(71.19+ (-10.38)). This implies that students exposed to brain-based strategy performed better than students exposed to the conventional method. The treatment explained about 83% ($Eta^2 = 0.8$) of the observed variance in students' performance in Mathematics. The two treatment strategies accounted for 88.1% ($R^2 = 0.881$) contribution to academic performance of the students in Mathematics.

H_o4: There is no significant interactive effect of treatment and gender on students' performance in Mathematics

In order to test the hypothesis, errors committed by students in science practical were collected from Mathematical Based Performance Test (MBPT). Univariate Analysis of Variance was used to compute interactive effect of treatment and gender on students' performance in Mathematics. The result is presented in Table 6.

Table 6: Univariate Analysis of Variance for interactive effect of treatment and gender on students' performance in Mathematics

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	31393.658[a]	5	6278.732	35.250	.000
Intercept	402763.812	1	402763.812	2261.219	.000
Treatment	28600.054	1	28600.054	160.568	.000
Gender	679.415	2	339.708	1.907	.000
Treatment * Gender	147.309	2	73.654	.414	.714
Error	31170.580	175	178.118		
Total	434745.000	181			
Corrected Total	62564.239	180			

a. R Squared = .302 (Adjusted R Squared = .292) p>0.05

The result presented in table 6 shows that there is no significant interactive effect of treatment and gender on students' performance in Mathematics as $F_{cal} = 0.414$, $P= 0.714>0.05$. This result led to the non-rejection of the null hypothesis. By implication, there was no significant interactive effect of treatment and gender on students' performance in Mathematics.

DISCUSSION

The findings of the study descriptively revealed that the performance of students between pre-test and post-test scores for experimental group is 34.78 while control group is 11.68. The findings of the study revealed that there was no significant difference in the pre-test mean scores of students in Mathematics in the experimental and control groups. This finding established the homogeneity of the two groups involved in the study prior to the experiment. In other words, it could be said that the knowledge baseline for the two groups involved in the study are equal. Consequently, any significant difference recorded afterwards would not be ascribed to chance, but to the specific treatment applied.

It was however revealed that there was significant difference in the post-test mean scores of students in Mathematics in the experimental and control groups. Students exposed to brain-based performed better than students exposed to the conventional method. This finding is in consonance with the findings of Duman (2010), Akyurek and Afacan (2013), Yagcioglu (2014), and Shabatat and Al-Tarawneh (2016) as they concluded that brain-based teaching approach significantly impact students' performance and attitude toward learning challenging science content.

The study further revealed that there was no significant interactive effect of treatment and gender on students' performance in Mathematics. This finding is in consonance with the findings of Saleh (2011) and Samur and Duman, (2011) that gender has no interactive effect when students were exposed to brain-based strategy. They indicated statistically significant results ($p < 0.05$) in the increase of academic achievement of students in experimental groups receiving brain-based instruction regardless of gender (Saleh, 2011; Samur & Duman, 2011; Shabatat & Al-Tarawneh, 2016).

CONCLUSION

Considering the findings of this study, it was concluded that, brain-based strategy was more effective and reliable than the conventional method. Students exposed to brain-based strategy performed better than those exposed to the conventional method in Mathematics. It was also concluded that there was no interactive effect of treatment and gender on students' performance in Mathematics

Contributions to Knowledge

1. The study highlighted the effects of brain-based strategy on students' performance in Mathematics.
2. The study provided information on how to improve students' achievement in Mathematics through the combination of the existing pedagogy and the introduction of brain-based strategy in order to facilitate productive development in Mathematics
3. It provided an insight into the influence of gender in the use of brain-based strategy on students' performance in Mathematics.

Recommendations

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

1. Brain-based strategy should be adopted as a means of instruction during Mathematics class. This will enable Mathematics teachers to pay more attention to individual students in teaching-learning process.
2. The Government in conjunction with the State Ministry of Education should expose Mathematics teachers to appropriate in-service training (seminars and workshops) to enhance professional competencies in their jobs. This will enable them to inculcate in their students, positive disposition towards Mathematics, which could further reduce the rate at which students fail Mathematics.

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