

UNIJERPS
Unizik Journal of Educational Research and Policy Studies Vol.4;
https://unijerps.org
2021 Impact Factor: 5.641; 2020 Impact Factor: 5.355.
January-June, 2021
Indexing and Impact Factor URL: http://sjifactor.com/passport.php?id=213

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FOSTERING SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN PHYSICS USING BRAIN-BASED LEARNING INSTRUCTIONAL STRATEGY

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Abstract

Science teaching in many schools has been done using didactic teacher-centered methods characterized by rote learning and memorization. This method of teaching has resulted in consistent poor achievement by students. The present study has therefore tried to find out whether and how a learner-centered instructional strategy such as "the brain-based learning (BBL) instructional strategy" could be used in fostering students' achievement in physics. The study adopted a quasi-experimental control group design. Two research questions and two hypotheses guided the study. Eighty-oneSS2 physics students drawn through multi-stage sampling approach from two co-educational secondary schools in Ohafia Education zone of Abia State, Nigeria constituted the sample. A researcher-constructed instrument tagged brain-based physics achievement test (Bb-PAT) was used to collect data. The Bb-PAT with the model answers was validated by experts. Kudar-Richardson formula 20 (KR-20) was used to establish the reliability of the instrument which yielded a reliability index of 0.76. The research questions were answered using mean and standard deviation while the hypotheses were tested at 0.05 alpha level using analysis of covariance (ANCOVA). The result showed that the experimental group performed significantly higher than the control group in physics. However, no significant gender influence on students' achievement was observed when acoustic concepts were taught using BBL instructional strategy. Recommendations were made based on the findings which included among others that federal ministry of education should consider including BBL instructional strategy as one of the learner-centered instructional strategies capable of enhancing students' achievement in physics.

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Keywords*: Brain-based learning, achievement in physics, rote learning and memorization.*

Introduction

Physics is globally regarded as the propeller of industrial and technological development. Sound knowledge of physics and utilization of its principles in technology is a sine-qua-non for any nation aspiring to be industrial and technological giant. As an important subject taught at the senior secondary level of education in Nigeria, physics offers the students an opportunity to engage in critical thinking, analytical reasoning and acquisition of spirit of inquiry among others (Jack, Danjuma & Gbadamosi, 2018). Due to its importance, physics has been made one of the major requirements for entry into science and technology-related courses in higher institutions all over the globe, Nigeria inclusive.

Unfortunately, despite the obvious awareness of the importance of physics to national development and more, students' performance still remains abysmal in the subject in internal, but especially external examinations. The situation could be attributed to a number of factors such as students' difficulty in understanding the underlying physics concepts as a result of absence of an effective strategy for impacting knowledge of such concepts, lack of well-equipped physics laboratories, shortage of qualified, experienced and committed physics teachers. It has been observed that physics teaching has been majorly done using teacher-centered methods like lecture and this does not yield much fruit in terms of producing sound and well-grounded scientists. Researchers have been investigating the effect of different learner-centered teaching strategies on students' achievement in physics (Nwankwo, Achufusi & Offiah, 2018; Nwankwo & Madu, 2014). One of those learner-centered approaches is the brain-based learning (BBL) approach which the researchers in this study wish to examine to see what effect it has on secondary school physics students' academic achievement.

Brain-based learning (BBL) according to Madrazo (2005) originates from research in neurology and cognitive science. The strategy examines how the brain works to understand how students learn and develop in a classroom. Olaoluwa and Ayantoye (2016) defines brain-based

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learning as a learner-centered and teacher-facilitated strategy that utilizes learner's cognitive endowments. The authors further stated that BBL approaches aligned with how brains naturally learn. This involves accepting the rules of how the brain organizes and processes instruction bearing these rules in mind, to achieve meaningful learning. The BBL is motivated by the general belief that learning can be accelerated and improved if educators base how and what they teach on the science of learning, rather than on past educational practices, established conventions or assumptions about learning process. Brain-based learning (BBL) refers to an advanced teaching strategies, lesson designs and school programmes that are based on the latest scientific research about how brain learns, including such factors as cognitive development; how students learn differently as they age, grow and mature socially, emotionally and cognitively. Applying brain research to instructional design can result in the practice of brain-compatible instruction instead of brain-antagonistic instruction (Stevens & Goldberg, 2001). As opined by Greenleaf (2003), BBL is an education which brings the learning system of brain forward, taking into consideration how brain accepts, processes, interprets information; makes connection, stores and remembers the messages

Brain-based learning (BBL)approach is believed to be more learner-friendly and boosts learning due to its holistic approach to learning, with the goal of attaining maximum attention, understanding, meaning and memory. BBL approach emphasizes meaningful learning instead of memorization. It does not easily learn things that are not logical or meaningful, hence structuring is important. As stated by Sousa (1995), BBL integrates the engagement of emotion, nutrition, enriched environment, music, movement, meaning-making and the absence of threat for maximum learner participation and achievement. The approach resists learning that decompose information, because naturally, the brain seeks to integrate information. This is why both teachers and learners should use stories, complicated subjects and metaphors in order to associate information and comprehension. To properly synthesize information, the brain does not function in a threatening environment. This function of the brain is called flow by psychologists and cognitivists (Abbott, 1997). As explained by Golman (2000), flow is a situation where an individual

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forgets himself, focuses on what he is doing and enjoys it. Caine and Caine (1991) and Caine, Caine and Crowell (1999)enumerated the following 12 principles of brain-based learning as follows:

1. The brain is a parallel processor.
2. Learning engages the entire physiology.
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 always involves conscious and unconscious processes.
9. We have at least two different types of memory: a spatial memory system and a set of systems for rote learning.
10. We understand and remember best when facts and skills are embedded in natural, spatial memory.
11. Learning is enhanced by challenge and inhibited by threat.
12. Each brain is unique. Hence, teaching should be programmed in a way that the students express their visual, auditory and emotional choices.

Knowledge of how the brain functions is necessary for any meaningful learning to take place. The brain of a student can learn only when the student is physically and emotionally safe, a situation which the teacher can create by providing a positive environment through motivation and praise. Research findings have shown that intake of water during learning time prevents students from being dehydrated, since dehydration can lead to loss of attention and lethargy (Aina & Ayodele, 2018). In the same vein, teaching should be punctuated with short breaks and exercises whereby students are allowed time to refresh, walk round, take snacks, drink water and take fresh air outside the classroom to refresh the brain if meaningful learning is to take place. One major characteristics of brain-based learning is interaction, both vertical and horizontal. Interaction in brain-based teaching model is identified into three categories according to Kaufman and Akers(2014) as:

1. Relaxed alertness: the aim of this approach is to present to students, a situation of low threat while at the same time engaging them in a

challenging task which brings the brain in a state of optimal learning.

2. Orchestrated immersion: here the learner is surrounded with interesting related hands-on activities that get them focused on the content.
3. Active processing: this involves the student being able to actively link information to prior learning, making it meaningful and conceptually harmonious. In this way, the information is consolidated and internalized.

Teaching strategies that enhance brain-based learning include manipulative, active learning, field trips, guest speaking and real life projects that allow the students to use many learning styles and multiple intelligence (Dumen, 2006). These strategies should be implemented at different levels and content areas in class using movement, music, stories, humours and metaphors. The first 15 to 20 minutes of the lesson should be utilized as effective teaching time by engaging students in brainstorming that is related to the concept being taught and using project and seminar presentations. Content-rich activities in the form of hands-on experiments, laboratory experiments, demonstrations and quantitative problem-solving should also be used. All these were aimed at fostering better achievement.

Achievement could be seen as being successful in any endeavour to which one is engaged. It is a practical evidence of somebody's claim. Daniels and Schouten in Mekonnen (2014) stated that academic achievement is the scholastic standing of a student at a given moment as explained in terms of the grades and performance on an educational achievement test and cumulative indicators such as educational degrees and certificates. Achievement is,in the view of Steinmayr, MeiBner, Weidinger and Werthwein (2015), a performance outcome that shows the extent to which a person has accomplished specific goals that were the focus of activities in instructional environments; specifically, in schools, colleges and universities. Nwankwo, Achufusi, Orafu and Aghado (2019) further maintained that academic achievement is a measure of output which in education are expressed in terms of learning, that is, changes in knowledge, skills and attitudes of individuals as a result of their experiences within the schools' system. In the context of this study which is done

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in secondary school, academic achievement is considered as the student's overall performance in the qualifying WASSC and/or NECO examinations. Poor academic achievement is a performance that falls below expected standard which is the minimum requirement for admission into institutions of higher learning.

Statement of the Problem

It has been observed over the years that teaching approaches used in teaching sciences, especially physics in many secondary schools are still concentrating on rote learning and memorization. This approach results in poor achievement of students in these subjects because whatever is learned though memorization and rote learning are not stored in the long term memory and so are easily forgotten. More so, these teacher-centered approaches only make the students act as receivers of information without thinking independently and actively processing the information received for better understanding. The problem, according to Dumen (2006), calls for the use of innovative and learner-centered alternative teaching methods that are enriched with the capability to create successful, creative, constructive, critical and probability based learning atmosphere and process for all students. The present study uses one of such enriched strategy, the brain-based learning strategy, to investigate its effect on secondary students' achievement in physics.

Research Questions

The following research questions guided the study

1. What are the mean achievement scores of secondary school physics students taught acoustics using BBL strategy and those taught using conventional approach?
2. What are the mean achievement scores of male and female secondary school physics students taught acoustics using BBL strategy?

Hypotheses

1. There is no significant difference in the achievement scores of secondary school physics students taught with BBL and those taught with CTA.
2. There is no significant difference in the achievement scores of male and female secondary school physics students taught with BBL.

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Research Method

The study adopted a quasi-experimental research design. Specifically, anon-equivalent control group design was used for the study. In this design, there was no randomization of participant to groups, rather intact classes were used since randomization would disrupt the school activities (Creswell, 2012). The population of the study was all physics students in the four local government areas of Ohafia education zone, Abia State, Nigeria. Eighty-one senior secondary two (SS 2) physics students drawn through multi-stage sampling approach from 74secondary schools in Ohafia Education Zone of Abia State, Nigeria constituted the sample. In the process of sampling, the first stage was to use simple random sampling technique (balloting) to select one out of the four local government areas (LGA) in the zone. Arochukwu LGA was thus selected. Next was the use of purposive sampling technique for the selection of two schools from the selected local government Area. The two selected schools have common characteristics which included well-equipped physics laboratories and experienced physics teachers with teaching qualification. To assign experimental and control treatments to the two selected schools, hat-draw method was used in which school A picked the head and was given experimental treatment using BBL while school B picked the tail and was used as control.

Brain-based physics achievement Test (Bb-PAT) was the instrument used for Data collection. The Bb-PAT was a 24-item multiple choice test developed by the researcher. The test items were selected from past questions of WASSCE, NECO and standard physics text books. Each item had four options with only one correct option. The items were developed using well-constructed Table of specifications presented as follows:

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Table of Specifications

Objectives → / Content ↓	%	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Totals
Definition/mode of production	12	2	1	-	-	-	-	**3**
characteristics of sound: Intensity, loudness, power, timbre and pitch (module2)	24	2	1	1	2	-	-	**6**
Sources of sound: pressure, musical instruments, human speech organ, loudspeakers (module 3)	20	-	1	2	1	-	1	**5**
Sound detectors: microphones (module 4)	16	1	-	2	1	-	-	**4**
Sound detectors cont'd: the human ear (module 5)	16	2	1	-	1	-	-	**4**
Revision, evaluation using post-test.	12	-	1	-	1	1	-	**3**
Total	**100**	**7**	**5**	**5**	**6**	**1**	**1**	**25**

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The instrument was validated by experts and its reliability was established using Kuder-Richardson formula 20 (KR-20) which yielded a reliability coefficient of 0.76, a value adjudged according to Nworgu (2015) as qualifying an instrument as reliable.

Two sets of tests were administered as pre- and post-tests. The pre-test was scored and kept without any feedback to the students. After the treatment, the same test with the same contents was reshuffled and administered as post-test. Both tests were scored by only one of the researchers to avoid bias. The results were used for analysis.

Experimental Procedures

The study was carried out in the second term of 2017/18 academic session using SS 2 physics students of the selected schools. The symbolic representation of the study design was shown as follows:

Group	**Pre-Test**	**Treatment**	**Post-Test**
BBL	O_1	X	O_2
---	---	---	---
CG	O_1	~X	O_2

Fig. 1: Symbolic representation of the research design,
where,
BBL = Brain-based (Experimental) Group
CG = Control Group
O_1 = Pre-test
X = Treatment using Brain-based approach
~X = No experimental treatment
O_2 = Post-test
----- = Two groups not equated by random assignment (Nworgu, 2015)

The experiment lasted for six weeks. The following sequence adapted from the work of Opaleye (2009) was followed in delivering the lessons:

Week 1: Introduction to acoustics: definition and mode of production of sound (module 1)

Week 2: characteristics of sound: Intensity, loudness, power, timbre and pitch (module 2)

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Week 3: Sources of sound: pressure, musical instruments, human speech organ, loudspeakers (module 3)

Week 4: Sound detectors: microphones (module 4)

Week 5: Sound detectors cont'd: the human ear (module 5)

Week 6: Revision and evaluation using post-test.

Each week had three periods (one single and one double) of 40 minutes. For the control group, the single period was used for normal teaching using conventional method. The double period was used for only such content-rich activities like demonstrations, experiments and quantitative problem-solving without engaging the students in brain-based activities. The students in the control group were required only to discuss and note down their observations. For the experimental class, the same concepts were taught for both single and double periods using brain-based approach.

To implement BBL, each lesson of the day was introduced with a song that students like and enjoy, but which is related to the day's topic. The students were then given some time (about 10-15 minutes) to interact and have discussion among themselves. This can be alternated with story-telling. The aim of the exercise is to create a relaxing atmosphere and remove all sorts of threat for students, thus creating a classroom setting that is physiologically safe and psychologically relaxing.

When the students are adequately relaxed, the day's topic is introduced. As the lesson progresses, a soft underground music plays and the lesson is punctuated with short and targeted related jokes and funs especially when the lesson becomes challenging. There was a break in between the lesson to enable students get relaxed by drinking water which they already have provided for themselves in order to avoid dehydration. It is also an opportunity for students to exchange views and brainstorm with their classmates on the lesson so far taught.

After the short break, students come back well-relaxed and motivated and are made to engage in orchestrated immersion by getting focused on a meaningful content of the lesson. This is done by sharing their individual experiences. Here the main and sub-themes of the topic were determined by

both the teacher and the students by the teacher brainstorming the students by asking leading and high order questions as well as providing suitable environment for curiosity. This is application of orchestrated immersion.

Students were also made not to allow factors such as students' examination scores, height, weight and the temperature of the classroom to bias or distort the outcome of the study. This is achieved by using different assessment tools for grading students like level of participation in class activities, faithfulness in the application of BBL strategies, extent of creativity and innovation ability observed in the student during challenging tasks and many more. Here teachers take note of the fact that every brain is unique and that the brain is a parallel processor and has a unique learning and interpretation capacity.

Results

The data presented in the following Tables are used to answer the research questions as well as to test the hypothesis at 0.05 level of significance.

Research question 1: What are the mean achievement scores of secondary school physics students taught acoustics using BBL strategy and those taught using conventional approach? Answer to this research question is provided in Table 1

Table 1: mean achievement and standard deviation scores of secondary school physics students taught with BBL and CTA

Teaching score approach	**pretest**			**post test**			**mean gain**
	N	Mean	SD	N	Mean	SD	
BBL	43	15.44	5.74	43	32.46	11.00	17.02
CTA38	12.65	5.89	38	19.57	11.62	6.91	

Table 1 shows the pre- and post-tests mean scores of students taught acoustic in physics using BBL instructional strategy to be 15.44 and 32.46 respectively while the mean gain score was 17.02. For the CTA group. the mean and standard deviation scores for pre- and post-tests were 12.65 and 19.57 respectively. The mean gain score for the CTA group was 6.91. The Table shows a higher post-test and mean gain

scores for the experimental group which signifies that BBL was efficacious in fostering students' achievement in physics

Research question 2:What are the mean achievement scores of male and female secondary school physics students taught acoustics using BBL strategy? Answer to research question 2 is provided in Table 2.

Table 2: mean achievement and standard deviation scores of male and female secondary school physics students taught acoustics using BBL strategy

Teaching approach	Gender	pretest			posttest			mean gain
	score	N	Mean	SD	N	Mean	SD	
BBL	Male	16	17.19	7.52	16	33.75	9.75	16.56
	Female	27	14.41	6.01	27	31.70	11.79	17.29

In Table 2, the pre-, post- and mean gain scores for male students were 17.19, 33. 75 and 16.56 respectively. Those of the female students were 14.41, 31.70 and 17.29 respectively. This shows that male and female students taught acoustic in physics did not differ much in their posttest achievement mean scores and mean gain scores.

Hypothesis Testing

1. There is no significant difference in the achievement scores of secondary school physics students taught with BBL and those taught with CTA.
2. There is no significant difference in the achievement scores of male and female secondary school physics students taught with BBL.

The test to hypotheses 1 and 2 are presented in Table 3

Table 3: Summary of analysis of covariance of students' achievement scores in physics by treatment and gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6449.391[a]	4	1612.348	28.090	.000
Intercept	2561.588	1	2561.588	44.628	.000
pretest	3010.431	1	3010.431	52.447	.000
group	1954.241	1	1954.241	34.046	.000
gender	10.262	1	10.262	.179	.674
Error	4362.338	76	57.399		
Total	67350.000	81			
Corrected Total	10811.728	80			

a. R Squared = .597 (Adjusted R Squared = .575)
b. Computed using alpha = .05

Hypothesis 1

The result in Table 3 revealed a statistically significant difference in the achievement scores of students taught acoustic in physics using BBL and those of control group taught using CTA, F (1, 76) = 34.046, P (0.000) <0.05. Hence, the hypothesis 1 was rejected. The implication being that there is a significant difference between the two groups in favour of the BBL group.

Hypothesis 2

From the same Table 3, one observes no statistically significant difference in the achievement scores of male and female students' when taught acoustic in physics using BBL, F (1, 76) = .179, P (.674) > 0.05. Sequel to the result, the hypothesis 2was rejected showing that BBL is gender-friendly.

Summary of Findings

The findings of the study are summarized as stated:

1. Students exposed to the concept of acoustic in physics using BBL had higher posttest achievement scores and greater mean gain scores than their counterparts of the control group taught using CTA. This was because a significant difference

existed in the posttest achievement scores of the two groups.

2. No gender influence was observed in the posttest achievement scores of students taught acoustic in physics using BBL because there was no statistically significant difference in the achievement scores of the students with respect to gender.

Discussion

The result of the study as shown in Tables 1and 2 revealed that students exposed to the concept of acoustic in physics using BBL instructional strategy performed better in their post achievement test than their counterparts in the control group taught using conventional approach. A significant difference existed between the achievement scores of the experimental and control groups in favour of the experimental group. This result is in consonance with the findings of Sani, Rothintaniawati and Winarno (2019) who in their work using BBL to promote students' concept mastery in learning electric circuit reported that BBL can improve concept mastery on electric circuit topic. Similar effect was earlier observed by Dumen (2016) in a study titled "the effect of brain-based instruction to improve on students' academic achievement in social studies instruction". The researcher observed that when one compares students exposed to BBL treatment, they performed significantly better than their counterpart taught using conventional method.

Furthermore, Jack, Danjuma and Gbadamosi (2018) equally supported the result with their finding on effect of BBL model on college of education students' retention and attitude in current electricity in Taraba State, Nigeria. In the study, using BBL instructional strategy, they observed 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, in turn, help them to gain success in achievement and retention. Affirming the result of the present study further, Awolola (2011) who studied the effect of BBL strategy on students' achievement in senior school mathematics in Oyo state, Nigeria noted that BBL instructional strategy enhances students' achievement in mathematics more than conventional lecture method.

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From Tables 2 and 3, it was noticed that gender has no influence on students' performance on Bb-PAT scores when taught Acoustics using BBL instructional strategies. This is inferred from the result which shows no statistically significant difference in the achievement scores of male and female students' when taught acoustic in physics using BBL, F (1, 76) = .179, P (.674) > 0.05. Hence, the BBL instructional strategy is considered to be gender-friendly. The result agrees with the findings of Saleh and Subramanian(2018) who reported in their work titled "effects of BB teaching method on physics achievement among ordinary school students" that BBL is capable of reducing achievement gap between male and female physics students. The reason is because the brain puts forward some basic principles such as considering the right and left brain tendencies, practicing real life experiences in learning, environment, establishing effective communication with learners and guiding learners through their learning processes among others. Still in support of the result of the study, Sela and Mazian (2019) reported that gender alone did not affect students' physics conceptual understanding.

However, Akyurek and Afacan (2013) reported centrally to our finding from their study on effect of BBL approach on students' motivation and attitude levels in science class that gender has significant effect on students' motivation towards science learning in favour of males.

From the on-going discussions, the effectiveness of BBL instructional strategies in fostering students' achievement in physics is undebatable. It was also clear from the on-going discussion that this learner-centered instructional strategy is also gender insensitive.

However, there is still need to carry out further research on the implementation of this strategy in the classroom so as to come up with a sharper definition of how best to implement it in the classroom while teaching students.

Conclusion

Brain-based learning instructional strategy has been found to be effective in fostering students' achievement in acoustic topics in physics. This is because of higher academic achievement scores registered by students in the Bb-PAT when taught the concept of acoustics in physics using BBL instructional strategy than when taught

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the same concept using conventional approach. From the result of the study however, there was no significant gender difference on physics students' academic achievement when taught the concept of acoustic using BBL instructional strategies. The little difference that was observed could be attributed to factors other than gender. The study threw wider light on the effects of BBL on improving students' achievement in physics.

Recommendations

Stemming from the findings of the study, the following recommendations were proffered:

1. Brain-based instructional strategies should be incorporated as one of the leading learner-centered approach to be adopted in Nigerian secondary schools by the federal ministry of education.
2. Teacher training designers should incorporate brain-based instructional strategies as a course of study in its programme.
3. Curriculum planners should review the science curriculum to incorporate BBL instructional strategies while text book authors should quickly begin to prepare adequate textbooks on the strategy.

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