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Enhancing Students' Conceptual Understanding in Physics using Brain-Based Learning Instructional Approach

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The study examined how brain-based learning (BBL) instructional approach could be used to enhance SS 2 physics students' conceptual understanding of the concept of projectiles. An 18-item physics concept evaluation (PCE) developed by the researcher was used for data collection from a sample of 97 SS 2 students offering physics using pretest posttest. The sample was selected using multi-stage sampling technique. The instrument was validated by experts. Kuder-Richardson formula-20 was used to establish the reliability of the instrument which yielded a reliability index of 0.81. Two research questions and three hypotheses guided the study. The research questions were answered using mean and standard deviation while the hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). The result indicated that BBL instructional approach can be used to enhance SS2 physics students' conceptual understanding of the concept of projectiles; students in rural school outperformed their counterparts in urban school when exposed to BBL. The interaction effect of instructional approach and school location was not significant (P <0.05). Recommendations were made which included among others that physics teachers should strive to explore the application of BBL in the classroom instruction.

INTRODUCTION

There is a rapid advancement in science and technology worldwide. In line with this, there is urgent need for corresponding adjustment in the manner of delivering science especially physics concepts to the students. The implication is that the orthodox or traditional teaching methods as presently used are no longer adequate since they make students only act like receivers of information sent by the teachers, thus denying them the opportunity to think independently and process such information using their brain. This is why Aziz (in Shabatat & AlTarawneh, 2016) stated that teaching approaches are still concentrating on memorizing.

Most science teachers often struggle to cover the syllabus as stipulated by the curriculum at the expense of the students' brain. Such teachers and the students seem to forget that there is a connection between the brain and everything that goes on in school. According to Jensen (2014), any attempt to disconnect the brain with the curriculum contents will lead to failure, frustration, and disaster in teaching and learning as is witnessed in science, especially physics education today in Nigeria. The students on many occasions had too much which the brain cannot cope with. This is why students can receive several hours of lessons without assimilating much. Most teachers forget that the human brain is like an individual who requires conducive and enabling environment to function well. The learning environment as seen presently in Nigeria are deplorable and hence, the brain reacts resulting in poor performance on their part. For this reason, educators and psychologists came up with Brain-based learning instructional approach, a refinement of teaching process using neurocognitive concept (Shabatat & AITarawneh, 2016).

Brain-based learning (BBL) as defined by Sani, Rochintaniawati & Winarno (2019) is a student-focused and instructor encouraged methodology that uses students' intellectual gifts and accentuating important learning. It is an education strategy which brings the learning system of the brain forward, taking into cognizance how the brain receives, processes and interprets information. BBL, being student-centered learning utilizes the whole brain and recognizes that not all students learn in the same way. It is also an active process where students are actually engaged in constructing their own knowledge in a variety of learning situations and contexts (Caine & Caine, 1994, 1997). BBL is therefore anchored on the constructivism theory.

The theory on constructivism hinged on the understanding that the students should be able to use the previous experience to construct new information and knowledge; an essential situation for learning in science education as Aina (2017) explained in his paper "Developing a constructivist model for effective Physics learning." The brain therefore helps the students to actively process the new information as a result of the storage in the spatial memory system making it possible for the students to naturally remember the experience without any rehearsal because it connects with the new information to learn. This exemplifies the principle that the brain understands and remembers best when facts and skills are embedded in natural spatial memory. Using BBL instructional method, learning becomes more expressive because the brain supports the processes in search of meaning and patterning. BBL is best favoured in a brain based classroom.

BB classrooms are called brain-friendly places (BFP). Such places as opined by Fogarty (2002) are learning environments where the brain functions and their role in learning are regarded in terms of teaching and learning processes. BFPs are emotionally-enriched environment where learners are immersed into challenging experiences. In BFPs, learners are unique and former knowledge serves as a baseline for new learning including a situation where learners are encouraged to acquire skills. Such places are richly equipped with resources as bulletin boards, aquaria where needed, various models, computing facilities and simulations. Lesson plans are flexible and serve learners' emotional needs; teachers are able to link secondary school courses with their sub-disciplines as well as other disciplines. For instance, physics courses are linked with related issues in chemistry, biology, mathematics, and even related professional courses like engineering, pharmacy and others. This integration of courses makes them more meaningful and interesting for learners. In BFPs, teachers can, for instance, integrate refraction in physics with concept of colour in Art.

Uzezi & Jonah, (2017) further recommends that in Brain-Based Learning, educators must submerge students in perplexing, intuitive encounters that are both rich and genuine, stating that the meaningful challenge can stimulate students' mind to the desired state of alertness required for meaningful learning to take place. The teachers should support more physical activities, recess and classroom movement. The brain need all these to function at its best. The nature of cognition, the functioning of the human brain and the construction of knowledge are tied to one another.

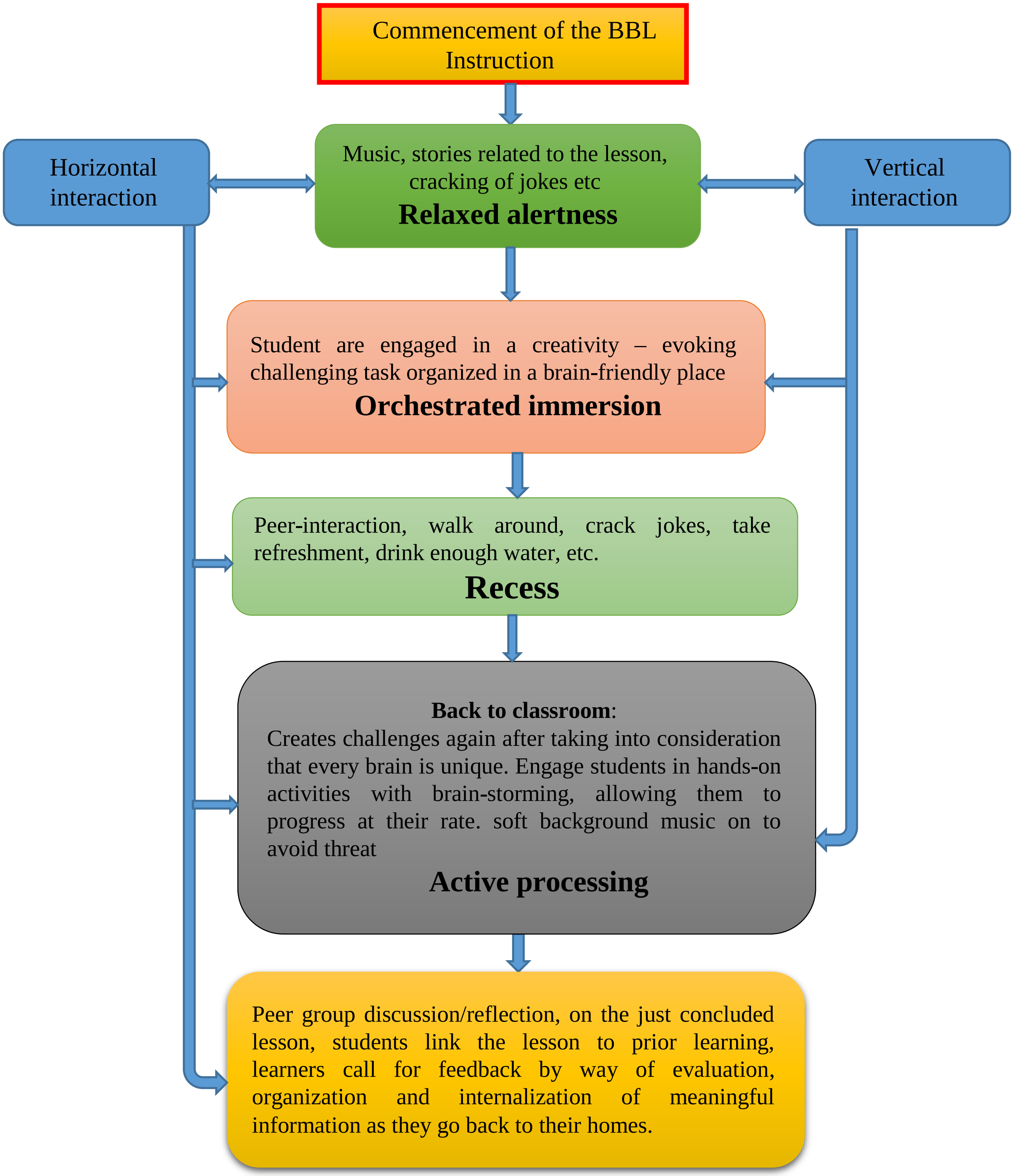

Fig 1: the BBL conceptual framework (Adapted from Aina & Ayodele, 2018)

Figure 1 is the Brain-Based Learning-conceptual framework as adapted from Aina & Ayodele, (2018) by the researcher.

The brain-based learning utilizes twelve principles as listed below according to Caine & Caine (1990). These are: the brain is a parallel processor, learning engages the entire physiology, the search for meaning is innate, the search for meaning occurs through patterning, emotions are critical to patterning, every brain simultaneously perceives and creates parts and whole, learning involves both focused attention and peripheral perception, learning always involves conscious and unconscious processes, we have two types of memory systems: spatial and rote learning, the brain understands and remembers best when facts and skills are embedded in natural spatial memory, learning is enhanced by challenge and inhibited by threat and finally every brain is unique.

The brain-based learning also valued interactions during the class teaching as very useful. These could be teacher-student (vertical) or students-students (horizontal) interactions. Kaufman and Akers (2014) identified three crucial interactive teaching strategies used in BBL which are:

1. **Relaxed alertness**: This means challenging learners in a proper way but with a low level of threat (Caine & Caine, 1995). Learners need to feel secure so that they can take risks. If the objective is to change the thinking styles of learners through establishing associations between the old and new knowledge, then learners need to be secure and require a challenging relaxed alertness.

2. **Orchestrated immersion**: in orchestrated immersion, learners are surrounded with a learning environment that is interesting, related and enriched with hands-on activities. Orchestrated immersion and relaxed alertness play a significant role in the ongoing process of searching for meaning in the brain.

3. **Active processing**: Active processing is the theoretical organization and internalization of the meaningful information by learners. Here information is linked to prior learning and the student is allowed to process the information actively (Caine & Caine, 1997; Sousa, 1995).

As Materna (2000) states, the brain struggles to form meaningful patterns from experiences as it processes information. Learners make associations in order to set up permanent learning prior to grasping the newly encountered information and storing it for further use. Integration of all these in the classroom is a major factor that makes BBL a very interesting and effective instructional strategy which is capable of bringing about in students, deep understanding of the concepts in physics.

Conceptual understanding in the view of Johnson (2005) is a person's ability to see connectedness between concepts and procedures as well as being able to apply a given principle in a variety of contexts and explaining why some facts are consequences of others (National Research Council, 2001). Integration and functional grasp of science especially physics ideas are very useful components in conceptual understanding. Students with conceptual understanding knows why an idea is important and the kind of contexts in which it is useful. They have organized their knowledge into a coherent whole which enables them to transfer what is learned in one situation to a different area of study. Rote learning has no place in conceptual understanding. Conceptual understanding involves seeing the connection between concepts and procedures. This is why when concepts are understood, facts are no longer isolated, but become organized in coherent structures based on relationships, generalizations and patterns (Nworgu & Ugwuanyi, 2014).

Another factor worth investigating is how school location effect students' conceptual understanding when students are taught using brain-based learning instructional approach.

School location according to Okorie and Ezeh (2016) is particular place in relation to other areas in the physical environment (urban and rural) where the school is sited. Oredein (2016) posited that though human beings have unlimited capacity to learn, they may however be limited by the behavior patterns and facilities that the immediate environment offers. Adebule and Aborisade (2013) observed that students who live in urban centers especially where there are tertiary institutions are likely to have inclination for higher education than those in rural areas.

Urban schools are also favoured in the distribution of human and material resources. It is not any news that experienced teachers hardly accept postings to rural schools. Furthermore, in terms of distribution of material resources, the situation is even worse. In 2009, for instance, the Federal Government of Nigeria equipped 474 schools in the country with internet facilities (Aginam, 2009 in Okwor, 2011). Similarly, Anambra state Government and some philanthropists equipped some schools with Information, Communications and Technology (ICT) gadgets but not many of the schools especially the ones located in rural areas benefited from the gesture. It is therefore of great importance that in addition to providing these tools and amenities, extra efforts should be put in place to ensure that they are equitably distributed to both rural and urban schools as well as ensuring that they be functional too. This has posed a great problem in many states in Nigeria and also in most developing countries. Mulemwa (2002) posited that the majority of countries in Africa experience a serious urban-rural divide due to drastic difference in between the facilities and opportunities available in the urban and rural areas. This view was supported by Olamiju and Olujimi (2011) who reported that most schools in remote (rural) areas in Ondo State were not serviced with educational facilities and that teachers were more concentrated in urban schools due to lack of necessary facilities in the rural areas. However, rural school offer the advantage of small class size which promises increased students evaluation, provides greater flexibility in teaching strategy and allows for better class control.

Effect of BBL on students

The following, according to Ozden and Gultekin (2008), are the effects of BBL on students:

1. Learners grasp the gist of how learning takes place since they are actively involved in the learning process

2. Learners discover that learning depends on their abilities to externalize their knowledge rather than their scores in examinations
3. Learners understand that knowing how to think will support their studies

Evaluation Using BBL Instructional Approach

While using BBL instructional technique, a reliable evaluation should involve these five components namely: the context, emotions, physical environment, the process and the organization. In the view of Jensen (2000), these areas involve mental, physical and emotional processes as well as past, present and future.

Statement of the Problem

Poor academic performance of students in physics as a result of lack of conceptual understanding of physics concepts has become a threat to national development. It has also been observed that such poor performance of students in physics is grossly linked to the method of teaching the subject to students among others. The conventional (lecture) method presently used in teaching physics does not encourage conceptual understanding of the subject and this eventually results in poor academic performance of such students in qualifying examinations. To combat misconceptions in physics and enhance deep understanding of physics concepts, it is necessary to review the methods of teaching the subject to students. Such methods that will engage students' entire physiology and recognize the uniqueness of each individual learner, making him emerge as holistic learner will go a long way to develop in students conceptual understanding of physics concepts. The present study therefore investigates one such method - the Brain-based learning instructional approach to ascertain its effect in enhancing students' conceptual understanding in physics.

Purpose of the Study

This study was done to investigate how BBL instructional approach could be used to enhance students' conceptual understanding in physics. Specifically, the study examined the:

1. effect of BBL in enhancing conceptual understanding of physics concepts among SS 1I physics students in Anambra State.
2. influence of school location on SS1 I physics students' conceptual understanding in physics when taught using BBL instructional approach in Anambra State.
3. Interaction effect of treatment and school location on SS 1I physics students' conceptual understanding in physics in Anambra State.

Research Questions

The following research questions guided the study:

1. What is the effect of BBL in enhancing conceptual understanding of physics concepts among SS I1 physics students in Anambra State?
2. What is the influence of school location on SS I1 physics students' conceptual understanding when taught using BBL instructional approach in Anambra State?

Hypotheses

The following hypotheses were tested at 0.05 alpha level:

1. There is no significant difference in the conceptual understanding of physics concepts among SS I1 physics students in Anambra State when exposed to BBL instructional approach.
2. There is no significant difference in the conceptual understanding of SS 11 physics students in the urban and rural schools when taught physics concepts using BBL instructional approach in Anambra State.
3. There is no interaction effect of treatment and school location on SS 11 physics students' conceptual understanding in Anambra State.

METHOD

The design of the study was quasi-experimental. Brain-based learning instructional approach has been selected as independent variable while conceptual understanding has been selected as dependent variable. The specific research design was a non-equivalent, control groups design involving pretest-posttest. The research subjects were not randomly assigned to the groups since randomization will disrupt the school activities.

The study design is symbolically represented as:

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

Fig. 1: Symbolic representation of the research design

where;

BG = Brain-based learning (Experimental) Group
CG = Conventional (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 population of the study consisted of all SS 11 physics students in all the 61 secondary schools in Awka Education Zone of Anambra State, Nigeria. Multi-stage sampling approach was used to constitute the sample. Purposive sampling technique was firstly used to select two schools in the zone (one urban and one rural) that are known to have two arms of physics classes together with qualified, registered, well experienced teachers as well as having well–equipped and functional physics laboratories. The next stage was using simple random sampling technique, specifically balloting to constitute two experimental and two control groups, one from each school. A total of 97 students were used for the study, 62 from urban and 35 from rural schools. For the experimental group, 34 and 19 students were used from urban and rural schools respectively totaling 53 students while 28 and 16 were used as control totaling 44 students. Instruction in the control groups was carried out using the conventional teacher-centered approach while in the experimental group instruction was done in accordance with brain-based learning and teaching principles. Data collection was done using physics concept evaluation (PCE). The PCE consists of 18-item short answer questions designed to ascertain the level of students conceptual understanding of concept of projectiles in physics. The test items were selected from past questions of WASSCE, NECO and standard physics text books. The instrument has four options, A - D. Each item has a score that exposes the learner's level of conceptual understanding of the concept under study. Hence 3 = sound understanding (SU); 2 = partial understanding (PU), 1 = alternative conception and 0 = no conception. Sound understanding represents the most acceptable scientific conception; partial understanding shows a situation where learner has abandoned his / her naïve conception but has not fully grasped the scientific conception, alternative conception represents a situation where the learner has not actually dropped his naive or alternative conception while no conception is scored when the respondent did not give any answer to the question. The test items and their model answers were validated by experts to ensure that it measures what it is supposed to measure. The reliability of the instrument was established using Kuder-Richardson formula-20 and the reliability index was found to be 0.81

The items were developed using well-constructed Table of specifications presented as follows:

Table of Specifications for PCE

Objectives → / Contents ↓	%	knowledge	comprehension	application	analysis	synthesis	evaluation	Totals
Concept of Projectiles	25	2	2	-	-	-	-	4
explanation of terms used in projectiles	25	2	3	-	-	-	-	5
Analysis of projectile motion with constant acceleration	25	-	2	1	2	-	-	5
Application of projectile motion in everyday life and warfare	25	-	1	3	-	-	-	4
Totals	**100**	**4 (22.2%)**	**8 (44.4%)**	**4 (22.2%)**	**2 (11.1%)**	**- -**	**- -**	**18 (100%)**

RESULTS

In the following Tables, 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)

Research Question 1

What is the effect of BBL in enhancing conceptual understanding of physics concepts among SS I1 physics students in Anambra State?

Table 1: Effect of BBL in enhancing conceptual understanding of physics concepts among SS I1 physics students in Anambra State.

		Pre-test			**Posttest**		**Gain in mean**
Group	N	Mean	SD	N	Mean	SD	
BBL	53	23.56	10.88	53	47.86	14.87	24.30
Conventional	44	26.09	10.97	44	41.80	11.36	15.71
TOTAL 97							

The result in Table 1 reveals that physics students taught using BBL instructional approach performed better with a pre- and posttest mean conceptual understanding scores of 23.56 and 47.86 respectively, while their gain in mean scores were 24.30. Their counterparts taught the same concepts in physics using conventional method had pre- and posttest scores of 26.09 and 41.80 respectively and a gain in mean score of 15.71.

Research Question 2

What is the influence of school location on SS I1 physics students' conceptual understanding scores when taught using BBL instructional approach in Anambra State?

Table 2: Influence of school location on SS I1 physics students' conceptual understanding scores when taught using BBL instructional approach in Anambra State.

School Location	N	**Pre-test** Mean	SD	N	**Posttest** Mean	SD	**Gain in mean**
Urban	62	26.74	10.53	62	44.19	12.72	17.45
Rural	35	21.11	10.88	35	46.74	15.25	25.63
TOTAL 97							

The result in Table 2 reveals that rural students taught using BBL instructional approach performed better with pre- and posttest mean scores of 21.11 and 46.74 respectively and a mean gain score of 25.63. Their counterparts exposed to the same physics concepts in urban school and using the same BBL instructional approach had pre- and posttest mean scores of 26.74 and 44.19 with a gain in mean score of 17.45.

Hypotheses

The following hypotheses were tested at 0.05 alpha level:

1. There is no significant difference in the conceptual understanding of physics concepts among SS I1 physics students in Anambra State when exposed to BBL instructional approach.
2. There is no significant difference in the conceptual understanding of SS 11 physics students in the urban and rural schools when taught physics concepts using BBL instructional approach in Anambra State.
3. There is no Interaction effect of treatment and school location on SS 11 physics students' conceptual understanding in Anambra State.

Table 3: Summary of Analysis of Covariance (ANCOVA) of students' scores in post treatment response by treatment and school location.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	9767.896[a]	4	2441.974	27.519	.000	
Intercept	8590.360	1	8590.360	96.806	.000	
pretest	8132.366	1	8132.366	91.645	.000	
group	1611.538	1	1611.538	18.161	.000	S
location	845.119	1	845.119	9.524	.003	S
group * location	177.300	1	177.300	1.998	.161	NS
Error	8163.857	92	88.738			
Total	215348.000	97				
Corrected Total	17931.753	96				

Hypothesis 1:

The test of hypothesis one is also presented in Table 3. The data presented in Table 3 showed that there is statistically significant difference in the conceptual understanding scores of students taught projectile concepts in physics using BBL instructional approach $F(1,92) = 18.161$, $P(.000) < 0.05$. This calls for the rejection of hypothesis one. There is therefore a statistically significant difference in the conceptual understanding scores of students taught projectile concept in physics using BBL instructional approach

Hypothesis 2:

The test of hypothesis two is also presented in Table 3. The data in Table 3 showed that there is statistically significant difference in the conceptual understanding scores of urban and rural students taught projectile concept in physics using BBL instructional approach $F(1,92) = 9.534$, $P(.003) < 0.05$. Hypothesis two was therefore rejected. Hence, there is a statistically significant difference in the conceptual understanding scores of urban and rural students taught projectile concept in physics using BBL instructional approach in favour of rural students.

Hypothesis 3:

The test of hypothesis 3 is still presented in Table 3. The data in Table 3 showed that there is no statistically significant interaction between teaching approach and school location on students' conceptual understanding scores in physics using BBL instructional approach $F(1,92) = 1.996$, $P(.161) > 0.05$. By this, hypothesis three was therefore not rejected. This implies that the interaction between teaching approach and school location on students' conceptual understanding scores in physics using BBL instructional approach was not statistically significant.

Findings of the Study

The findings of the study are summarized as follows:

1. Experimental group taught the concepts of projectile in physics using BBL instructional approach had higher posttest conceptual understanding scores and greater gain in mean scores in conceptual understanding than those of control group taught the same concepts using conventional method. There is therefore a statistically significant difference in the conceptual understanding scores of the students taught using BBL than their counterparts taught using the conventional method.
2. Students in rural school exposed to the concepts in projectile motion in physics using BBL instructional approach performed better than those in urban school taught the same concepts and using the same method
3. The study shows no statistically significant interaction between teaching approach and school location on physics students' conceptual understanding scores.

DISCUSSIONS

From the result of the study as seen in Table one, students taught physics using BBL instructional approach performed better than their colleagues taught the same concepts using conventional method. The findings agree well with the observation made by Caulfield, Kidd and Kocher (2000) who reported that BBL effects the students' academic, attitudes and motivation positively. The result was further supported by that of Noureen, Awan and Fatima (n. d.) who reported that BBL showed better result than conventional method by improving academic scores and enhancing the working of the brain. Duman (2006) further added that the effectiveness of BBL is due to provision of positive mood for learning which is quite conducive for performance.

Also Sani, Rochi and Winarno (2019) supported our result by stating that BBL teaching approach was more effective in developing students, conceptual understanding than conventional method.

With regard to school location, the study result showed that students in rural school outperformed their counterparts in urban school when taught using BBL instructional approach. The findings disagree with most studies that urban students performed better than rural students (Igboegwu & Okonkwo, 2012; Adebule & Aborisade, 2013). The difference in result could be due to the fact that students in rural schools are more relaxed and are free from unnecessary distractions that exist in urban environments. This relaxed mood and the simple life style in rural areas according to Alordiah, Akpodia and Oviogbodu (2015) to a great extent favours the application of BBL instructional strategy. The result of this study also disagreed with the findings of Obioma (1985) and Kissau (2006). Obioma (1985) observed that students in urban areas perfumed better in achievement test than those in rural area while Kissau (2006) reported that students all performed well in achievement test irrespective of school location. Josaiah (2012) used computer assisted instructional (CAI) method to teach physics students and observed no significant difference in physics achievement between the urban and rural students exposed to learning physics using CAI.

The findings also revealed that there was no interaction effect between BBL instructional strategy and school location on students' conceptual understanding of concept of projectiles in physics. This was further affirmed by the ANCOVA result on Table 3 which shows that the interaction effect between teaching method-BBL and school location was not significant. This implies that school location did not combine with instructional strategy to affect the student' conceptual understanding in physics. hence, one may begin to appreciate the fact that the simple main effects of the BBL instructional strategy do not change as a function of variations in school location and vice versa. The finding however disagreed with that of Agboghoroma (2009) who discovered significant interaction between guided discovery instructional method and school location on integrated science students' knowledge in Nigeria. Amadi (2018) also found a significant interaction effect of teaching method and location on achievement in reading.

CONCLUSION

The outcome of the study shows that BBL instructional strategy is capable of enhancing physics students' conceptual understanding of concepts of projectiles since the students exposed to the concept of projectiles using BBL instructional strategy performed significantly better than those of conventional approach. Secondly, it was observed that students in rural school benefited more from the approach when compared with their counterparts in urban school. Finally, no interaction effect was observed between the approach and school location on students' conceptual understanding.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were proffered:

1. The school authorities and significant stakeholders in education should jointly encourage and promote the use of BBL instructional strategy in secondary schools in Nigeria.
2. Teacher training institutions should incorporate BBL as a technique in physics method course content in order to ensure that physics teachers are adequately and professionally trained on the use of the strategy. Regular in-service courses should be organized for those already in the field by ministry of education.
3. Textbook authors should strive to produce adequate textbooks on BBL instructional strategy.
4. Physics teachers should strive to explore the application of BBL in the classroom instruction as the task is enormous

REFERENCES

Adebulu, S. O. & Aborisade, O. J. (2013). Influence of study interest and school location on the attitude of secondary school students towards mathematics in Ekiti State, Nigeria. *Greener Journal of Educational Research, 3* (6), 229-232.

Agboghoroma, T. E. (2009). Interaction effects of instructional mode and school setting on students' knowledge of integrated science. *International journal of scientific research in education (IJSRE), 2* (2), 67-75.

Aina, J. K. (2017). Developing a constructivist model for effective physics learning. *International Journal of Trend in Scientific Research and Development, 1*(4), 59-67.

Aina, J. K. & Ayodele, M. O. (2018). The Application of Brain-Based Learning Paradigm in Science Education, Nigeria: A Review. *Journal of Scientific and Engineering Research, 5*(7), 325-331.

Alordiah, C. O., Akpadaka, G. & Oviogbodu, C. O. (2015). The influence of gender, school location and socio-economic status on students' academic achievement in mathematics. *Journal of Education and Practice, 6* (17), 130-136.

Amadi, E. A., Nnamani, A. P. & Ukoha, E.O. (2018). School location as a predictor of achievement in reading among Nigerian learners of English as a second language. *Covenant journal of language studies (CJLS), 6* (2), 65-73.

Caine, R. N. & Caine, G. (1990). Understanding a brain-based approach to learning and teaching. *Educational Leadership, 66-70*.

Caine, G. & Caine, R. N. (1994). *Making connections: teaching and the human brain.* Menlo park, CA: Addison-Wesley.

Caine, R. N. & Caine, G. (1997). *Education on the edge of possibility*. Alexandria, VA: ascd.

Caulfield, J., Kidd, S. & Kocher, T. (2000). Brain-based instruction in action. *Educational leadership, 58* (3), 62-65.

Duman, B. (2006). The effect of brain-based instruction to improve on students' academic achievement in social studies instruction. *9th international conference on engineering education, July 23-28*.

Jensen, E. (2014). Jensen learning guide to brain-based teaching. Retrieved July 14, 2018, from *http://www.jensenlearning.com/wp-content/uploads/2016/07/10MostEffectiveTips.pdf.*

Johnson, S.K. (2005). Conceptual and procedural knowledge in mathematics: an introductory analysis. Conceptual and procedural knowledge: the case of mathematics (p. 1-27). Hillsdale, NJ: Erlbaum. Retrieved from *Http://Wik.Ed.Uiuc.Ed/Index.Php/Conceptual Knowledge.*

Josaiah, M. M. (2012). School location versus academic achievement in physic. Does computer assisted instruction has any effect? *Journal of education and social research,6* (8), 162-168

Kaufman, E.K., & Akers, C. (2014). Engaging students with brain-based learning. Retrieved from *https://www.researchgate.net/publication/253117676*

Kissau, S. (2006). Gender difference in motivation to learn French. *Canadian modern language review, 62* (3), 65-96. In Africa, 22-29

Mulenwa, J. (2002). The challenges of providing quality school science in Africa. *Proceedings of 43rd annual conference of the science teachers association of Nigeria (STAN)* on science, technology and mathematics education for sustainable development

National Research Council. (2001). *A framework for k-12 science education: practices, crosscutting concepts and core ideas. Washington, DC*: national academies press.

Noureen, G., Awan, R. N. & Fatima, H. (n. d). Effect of Brain-based Learning on academic achievement of V11 Graders in mathematics. *Journal of elementary education, 27* (2), 85-97.

Nworgu, B. G. (2015). *Educational research: basic issues and methodology.* Ibadan, wisdom publishers limited.

Nworgu, B. G. & Ugwuanyi, C. S. (2014). Assessment of senior secondary school physics students' conceptual understanding of force and motion. *Journal of science teachers association of Nigeria, 49* (1), 170 - 186.

Obioma, G. O. (1985). THE development and validation of a diagnostic mathematics achievement test for Nigerian secondary school students. *Journal of mathematics association of Nigeria, 19* (1), 41-46.

Okorie, E. U. & Ezeh, D. N. (2016). Influence of gender and location on student' achievement in chemistry bonding. *Mediterranean journal of social sciences, 7* (3), 309-318.

Okwor, A. N. (2011). Nigeria's digital divide-cog in the wheel of vision 20-2020. *Journal of the science teachers association of Nigeria (JSTAN), 46* (1), 149-164.

Olamiju, I. O. & Olujimi, J. (2011). Regional analysis of locations of public educational facilities in Nigeria: the Akure region experience. *Journal of geography and regional planning, 4* (7), 428-442.

Oredein, O. (2016). Effects of school variables on students' academic performance in Calabar municipal area of cross river state. Retrieved 06/02/2021.

Ozden, M & Gultekin, M. (2008). The effects of brain-based learning on academic achievement of and retention of knowledge in science courses. *Electronic journal of science education, 12* (1), 1-15.

Sani, A.; Rochintaniawati, D. & Winarno, N. (2019). Using Brain-Based Learning to Promote Students' Concept Mastery in Learning Electric Circuit. *Journal of Science Learning, 2*(2), 42-49.

Shabatat, K., & Al-Tarawneh, M. (2016). The Impact of a Teaching Learning Program based on a Brain-Based Learning on the Achievement of the Female Students of 9th Grade in Chemistry. *Higher Education Studies, 6*(2), 162.

Sousa, D. (1995). How the brain learns. A classroom teacher's guide. Reston, VA: National association of secondary school principals.

Uzezi, J. G. & Jonah, K. J. (2017). Effectiveness of Brain-based Learning Strategy on Students' Academic Achievement, Attitude, Motivation and Knowledge Retention in Electrochemistry. *Journal of Education, Society and Behavioural Science*, *21*(3), 1–13. https://doi.org/10.9734/JESBS/2017/34266.

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