



## Enhancing Students' Conceptual Understanding in Mathematics using Brain-Based Learning Instructional Approach among Junior Secondary School students in Ekiti State, Nigeria

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### Abstract

*This study investigated the effectiveness of the Brain-Based Learning (BBL) instructional approach in enhancing students' conceptual understanding and academic achievement in Mathematics word problems among Junior Secondary School students in Ekiti State, Nigeria. Three research hypotheses were formulated for the study. The study adopted a pretest–posttest quasi-experimental research design. The population comprised 10,529 Junior Secondary School Two (JSS II) students in public secondary schools across the three senatorial districts of Ekiti State. A sample of 370 students drawn from nine selected schools participated in the study using proportionate and stratified random sampling techniques. Data were collected using a researcher-developed instrument titled Achievement Test on Brain-Based Learning on Mathematics (ATBBLM), which yielded a reliability coefficient of 0.89 using the split-half method. The experimental group was exposed to Brain-Based Learning instructional approach, while the control group was taught using the conventional teaching method. Data collected were analysed using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The findings revealed that students taught Mathematics using the Brain-Based Learning instructional approach performed significantly better than those taught using the conventional method. The study further showed that gender and school location had no significant influence on students' academic achievement when exposed to Brain-Based Learning. The study concluded that Brain-Based Learning instructional approach provides a more meaningful and supportive learning environment for Mathematics instruction than the conventional teaching method. It was therefore recommended that Mathematics teachers should adopt Brain-Based Learning strategies in classroom instruction, while educational stakeholders should organize regular training programmes to improve teachers' competence in learner-centred instructional practices.*

**Keywords:** Brain-Based Learning, Conceptual understanding, Mathematics achievement, word problems, Instructional approach, Secondary school students.

### Introduction

One of the disciplines in the school curriculum that requires logical reasoning and full use of the brain is Mathematics. Mathematics is the logical language for describing ideas of shapes, amounts, sizes, order, change, and dynamism in systems and for explaining the intricacies of modern society in business, economic, academic, engineering and medical settings (Okeke, 2013). Mathematics is a subject of study. Mathematics is studied by all students from elementary to Senior High Schools and even Universities (Asfar et al., 2022).

This is expedient as the materials included in Mathematics equips the mind of the student with logical, cognitive and analytical reasoning skills suitable in solving real world problem. Mathematics competence and learning are essential to solve everyday life problems (Kong &Matore, 2021). The application of Mathematics is not only restricted to

Science, Technology, Engineering and Mathematics (STEM) education, but its impact and importance span across other disciplines such as Humanities and social sciences.

It is a fact essential to all human pursuits. UNESCO (2012) supports this by stating that relevant and quality Mathematics education can foster critical and creative thinking, help learners understand and engage in public policy discussions, promote behavioural changes that can put the world on a more sustainable path, and stimulate socio-economic development. Mathematics is a social construct which is open to change, advancement and development despite its vastness (Uzoechi, et al., 2013).

Word Problem is an important topic in Mathematics education at all educational levels. It is often found in the subject matter such as Social Arithmetic, Statistics, Algebra, Physics and Economics and it serves many purposes in Mathematics education (Carlos, et.al., 2023; Pongsakdi, et. al., 2020, Nwankwo, 2021). Word problems demand students to read a language-based problem, extract information needed to answer a prompt, and conduct calculation(s) to generate a problem solution (Powell et al., 2019). It offers variation to the practising of basic Mathematical operations and educate students to employ Mathematical skills in everyday circumstances outside the classroom (Pongsakdi, et. al., 2020).

Mathematics achievement is frequently tested by standardized tests (Carlos et. al., 2023). Although the importance of word problem to real life cannot be over-emphasized, the academic performance of students in both internal and external standardized test given on word problems has not been encouraging. Poor performance in word-problem solving may affect students' later achievement in Mathematics in school, employment possibilities and salary later in life (Powell, et al., 2019). Students' difficulties with Mathematics, general language comprehension and Mathematics-specific language comprehension employed in the text of the word problems may influence the complexity of word problems (Fuchs et.al., 2018).

Students' poor performance in Mathematics could be due to many factors which include teaching strategies, teachers' attitude, lack of instructional materials, students' laziness, but little or no attention has been given to what is happening in Mathematics conceptual understanding appraisal (Olofin & Olojo, 2022). Observing pupils that take Mathematics assessments, some of the students that have enough knowledge or prepared properly, do not fare well in their Mathematics tests. Some students start preparing early, study well for the Mathematics test, but their performance does not match the preparation. This can be as a result of incorrect use or lack of brain-based strategy.

In their classroom lesson delivery, most Mathematics teachers have adopted the typical Teacher- centered method (Ibok, Esuong, & Joseph, 2023). This technique of teaching can be in form of conversation, offering of project, lecture, demonstration and discovery depending on the teacher. The lecture approach which is a commonly utilized method by Mathematics professors only concentrates on superficial learning instead of in depth knowledge of the facts (Asiyai, 2015). This does not bring out the intended outcomes because the student endures passive learning. Since for learning to occur teaching and learning Mathematics must be student-centred and not teacher-centred (Zain et al., 2012). Then it is of significant necessity to employ the learner focused method, rather than aiming to improve on the teacher-centred ways. The researcher in this study wants to see the conceptual comprehension of students in Mathematics with a Brain Based Learning (BBL) approach.

The Brain Based Learning (BBL) approach is a product of the study of neurology and cognitive science. According to (Nwankwo, 2021; Udofia & Ibok, 2025) brain based learning (BBL) is an innovative teaching strategies, lesson designs and school programmes



that are based on the most recent scientific research about the way brain learns, including such factors as cognitive development; how students learn differently as they age, grow and mature socially, emotionally and cognitively. It is an instructional technique that looks at students' achievement and learning goals through the lens of the human brain. It involves particular learning processes. It is concerned with how human memory, attention, motivation and conceptual cognitive learning functions. (Amjad et al., 2022)

This method is utilized in a brain-friendly, non-threatening classroom setting to enhance knowledge and minimise the usage of the traditional strategy that only promotes rote memorisation (Noureen et al., 2017). It shows how the brain is wired biologically to learn (Solihat, 2017). The brain-based learning (BBL) approach is believed to be more learner-friendly and boosts learning due to its holistic approach to learning. The goal is to attain maximum attention, understanding, meaning and memory. It is added that BBL approach emphasizes meaningful learning instead of memorization and that it does not easily learn things that are not logical or meaningful (Nwankwo, 2021). Considering the advantages of Brain-based learning, it is necessary for Mathematics teachers to utilize this approach when teaching Word problems in Ekiti State.

### Statement of the Problem

Mathematics is an important subject as far as Science, Technology and human growth is concerned. The proper use of the notion of Mathematics may be seen in the present day inventions and the growth of the nation. However, the method of instruction utilized in teaching Mathematics in some secondary schools is teacher oriented and the pupils become passive learners with little or no autonomous mental reasoning. In this strategy the learner is given the opportunity to memorize instead of understand and retain the lesson leading to poor academic accomplishment of students in Mathematics word problems.

The traditional methods have not enhanced the academic achievement of students in Mathematics, therefore the need to adopt one of the innovative and learner centered teaching approaches as an alternative to see whether it can enhance the Students' Academic Achievement and retention in Mathematics Word problems. The study aims to explore the conceptual understanding of students in Mathematics utilizing Brain-Based Learning (BBL) instructional strategy among Junior Secondary School students in Ekiti State.

### Purpose of the Study

The aim of the study is to determine the students' conceptual understanding in Mathematics using Brain-Based Learning Instructional Approach among Junior Secondary School students in Ekiti State.

### Research Hypotheses

The following hypotheses were formulated for the study:

1. There is no significant difference in the mean academic achievement of students in Mathematics when taught using brain-based learning compared with those taught using conventional approach.
2. There is no significant difference in the mean academic achievement scores of male and female students in Mathematics when taught using brain-based learning.
3. There is no significant difference in the mean academic achievement scores of rural and urban students taught word problems in Mathematics using brain-based instruction.



## Literature Review

### Concept of word problem in Mathematics

Word problem is an important topic in Mathematics. It is mathematical problems structured linguistically (Verschaffel et al., 2020) practiced at all levels of education and have enormous relevance to humanity. Studying Word problems exposes students to Mathematics in their day-to-day life through applying the knowledge acquired in the classroom to solve real world situations (Bullock, 2015). It can be classified as routine or non-routine jobs (Taley, 2022).

Routine problems are tasks whose solutions are inferred from the application of general Mathematics ideas gleaned from the problem circumstance. They are problems which are solved by step-by-step duplication of previously taught techniques (Esuong & Edoho, 2018). Non-routine difficulties are those jobs that do not explicitly indicate a predictable well-rehearsed approach or solution pathway.

Though word problems are seen to be important, (Taley, 2022; Pearce et al., 2013) states that student's distaste for word problems were founded on instructional related variables and student related aspects. They further explained that instructional-related criteria were the teaching technique, instructional language difficulty and the language utilised in framing the activities.

Student factors also included the mental and emotional disposition of students to word problems and students' inadequacy in the language utilized in developing Word problem as a medium of instruction (Esuong, Owan, Edoho & Eni, 2023). Their findings indicated that students' lack of understanding of word problems as a medium of instruction resulted in inadequacies in students' capacity to make meaning as proven elsewhere.

### Brain Based Learning Method

The Brain Based Learner strategy of teaching (Amjad et al., 2022) is one of the important teaching approaches to be explored in the twenty first century. Learning cannot take place without the brain, and the brain's structure and function contribute to the development of the ability to learn (Arun and Singaravelu, 2018). Brain Based Learning is about how our brain learns. (Amjad et al., 2022). It is a learner-centered and teacher-facilitated strategy that uses the cognitive endowments of learners (Gladys et al., 2018), based on the working of the brain and naturally intended to learn (Mekarina & Ningsih, 2017). Brain Based Learning is the process of adapting teaching processes of human brain to the learner-centred teaching processes (Koşar & Bedir, 2018).

This method of learning is different from traditional methods of teaching and according to Arun and Singaravelu (2018), brain based learning emphasizes meaningful learning in the place of rote learning. They further added that it is also a developed activity based learning and learner centric approach. Brain Based approach not only improves the academic accomplishment and retention of learners but also promotes cooperation, teamwork and dedication (Duncan, 2020) with permanent behaviour change as a result of establishing a knowledge based on practice and experience (Koşar & Bedir, 2018).

### Methodology

The pre-test post-test quasi-experimental design was used for this study. This design make used of pre-test and post-test in order to ascertain the effect of treatment together with the moderator variables. The population of this study comprise of 10529, JSS 2 students in public schools comprising of 5215 male and 5314 female students as at 2025/2026 academic

year, (Ekiti State Ministry of Education, Ado-Ekiti) in the two hundred and three (203) public secondary schools of the three (3) Senatorial districts (Ekiti South, Ekiti Central and Ekiti North).

The proportionate and stratified random sampling techniques were used to select a sample of three hundred and seventy (370) junior senior secondary two (JSS 2) students drawn from intact classes from the nine (9) selected schools in three (3) Senatorial districts. The samples were 159 males and 211 female students. In term of groups; 190 students were assigned to experimental group and 180 students for control group.

The instrument for data collection was a researcher-developed instrument titles: Achievement Test on Brain Based Learning on Mathematics (ATBBLM), a 25 items 4 option multiple choice test used for data collection after determining its validity and reliability indices validity involved face and content validity determination and item analysis. Spilt half method was used to determine the reliability index of the instrument, which was 0.89 (Table 1). The students were given code numbers to use in their scripts instead of their name. These code numbers were maintained in the pre-test and post-test exercises. The instrument was expected to measure the students, pre-test and post-test achievement in the experimental and control groups.

**Table 1: Split-half reliability estimates of the research instrument (N = 40)**

Instrument	No of Type item	Mean (x)	Standard derivation (SD)	Split-half correlate ( $r_{xy}$ )	Reliability estimate ( $r_{tt}$ )	
	20	Odd	94.17	5.70	.85	.89
	20	Even	109.32	16.32		

### Experimental Procedure

Permission was obtained from the authorities of the selected schools before the commencement of the study. The researcher interacted with the Mathematics teachers who taught the students on the concept of Brain-Based Learning. Thereafter, the Achievement Test on Brain Based Learning on Mathematics (ATBBLM) was administered as a pre-test to the two groups by the researcher with the assistance of the Mathematics teachers, and the scripts were collected immediately after completion for marking.

The treatment exercise commenced two days after the administration of the pre-test. The classroom teaching activities were conducted by the Mathematics teachers in each of the selected schools using the instructional packages prepared for the experimental group based on the Brain-Based Learning approach. Following the completion of the treatment exercise, the ATBBLM was reshuffled and administered as a post-test four days later. The test scripts were thereafter collected for marking and analysis.

For each correct option to items in ATBBLM was scored 4 marks and incorrect answer was scored zero (0). For gender, Male were scored – 1 and Female –2. The null hypotheses formulated for the study were tested using Analysis of Covariance (ANCOVA) at p-value = 0.05. This method of data analysis helps to eliminate differences between groups.

### Results

**Hypothesis 1:** There is no significant difference in the mean academic achievement of students in Mathematics when taught using Brain-Based learning compared with those taught using conventional approach.

One-way Analysis of Covariance (ANCOVA) was applied in testing this hypothesis with teaching method as factor (independent variable) and post-test achievement scores as dependent variable while pre-test achievement scores represented the covariate. The results obtained are presented in Table 2.

**Table 2: One-way ANCOVA of Students' Academic Achievement Scores by Teaching Method**

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	78.213 <sup>a</sup>	2	39.106	294.223*	.000	.002
Intercept	285060.261	1	285060.261	142.848*	.000	.854
Pretest	27.549	1	27.549	207.564*	.000	.733
Teaching Method	50.889	1	50.889	383.675*	.000	.001
Error	48821.520	367	133.029			
Total	2053911.000	370				
Corrected Total	48899.732	369				

a. *R Squared* = .002 (*Adjusted R Squared* = -.004)

The ANCOVA result in Table 2 revealed that after adjusting for the effect of covariate, the results still showed that the effect of teaching method was significant ( $F(1,367)=383.675$ ,  $p<.05$ ). The significant pretest effect, ( $F(1,367)=207.564$ ,  $p<.05$ ), shows that students' initial achievement levels significantly influenced their post-test performance. The corrected model was also statistically significant, ( $F(2,367) =294.223$ ,  $p<.05$ ), indicating that the combined predictors significantly explained variation in students' achievement scores. Also, the effect size for teaching method was substantial (Partial Eta Squared = .733), implying that the teaching method accounted for 73.3% of the variance in students' academic achievement scores. On the basis of this outcome, the null hypothesis was rejected. This means the difference between the mean Mathematics achievement scores (22.00) of students exposed to Brain-Based instruction and that of those taught with the conventional method is statistically significant.

**Hypothesis 2:** There is no significant difference in the mean academic achievement scores of male and female students in Mathematics when taught using Brain-Based learning.

To test this hypothesis, One-way Analysis of Covariance (ANCOVA) was applied with students' gender as independent variable and post-test scores in Mathematics as dependent variable while pre-test scores represented the covariate. The results obtained were presented in Table 3.

**Table 3: One-way ANCOVA of Students' Academic Achievement Scores by Gender**

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	162.014 <sup>a</sup>	2	81.007	.610	.544	.003
Intercept	279182.399	1	279182.399	2102.272	.000	.851
Pretest	43.983	1	43.983	.331	.565	.001
Gender	134.690	1	134.690	1.014	.315	.003
Error	48737.719	367	132.800			
Total	2053911.000	370				
Corrected Total	48899.732	369				

a.  $R$  Squared = .003 (Adjusted  $R$  Squared = -.002)

In Table 3, the ANCOVA analysis revealed that, after adjusting the post-treatment scores for the effect of covariate, gender had no significant influence on students' academic achievement in Mathematics, ( $F(1,367)=1.014$ ,  $p=.315$ ). Since the  $p$ -value exceeded 0.05, the null hypothesis was accepted. This indicates that male and female students performed similarly when taught using Brain-Based Learning. The effect size was negligible (Partial Eta Squared = .003), showing that gender contributed only 0.3% to the variation in students' achievement scores.

**Hypothesis 3:** There is no significant difference in the mean academic achievement scores of rural and urban students taught word problems in Mathematics using brain-based instruction.

To test this hypothesis, One-way Analysis of Covariance (ANCOVA) was applied with location as independent variable and post-test scores in Mathematics as dependent variable while pre-test scores represented the covariate. The results obtained were presented in Table 4.

**Table 4: One-way ANCOVA of Students' Academic Achievement Scores by School Location**

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	216.777 <sup>a</sup>	2	108.389	.817	.000	.004
Intercept	283358.284	1	283358.284	2136.117	.000	.853
Pretest	35.138	1	35.138	.265	.000	.001
Location	189.454	1	189.454	1.428	.233	.004
Error	48682.955	367	132.651			
Total	2053911.000	370				
Corrected Total	48899.732	369				

a.  $R$  Squared = .004 (Adjusted  $R$  Squared = -.001)

In Table 4, the ANCOVA result indicated that, after adjusting the post-treatment scores for the effect of covariate, the F-ratio test indicated that ( $F(1,367)=1.428$ ,  $p=.233$ ) as the respective P-values associated with computed F-values (.817, 2136.117 and .265) were less than .05. The effect size was also very small (Partial Eta Squared = .004), implying that school location accounted for only 0.4% of the variance in achievement scores. On the basis of this outcome, the null hypothesis was retained. This means that, there is no significant difference in the mean Mathematics achievement scores of urban and rural students taught Mathematics using brain-based instruction.

### **Discussion of Findings**

It was found that the conventional method was significantly lower than Brain Based Learning (BBL) instructional approach in achieving academic achievement in Mathematics. The difference between experimental and control groups is very high which indicates that BBL is more effective to enhance the conceptual understanding and achievement of students in Mathematics. The result is in line with Bilal's (2010) finding that BBL learners performed better than the traditional ones. This is also in line with the findings of Aaron A. et al. (2023) who conducted a meta-analysis that found that the use of BBL principles showed a large positive effect on students' conceptual understanding in all disciplines. The result is consistent with the claim of Arun and Singaravelu (2018) that Brain Based Learning fosters meaningful learning than memorization which enhances learner's understanding and retention. Likewise, Nwankwo et al. (2021) argued that BBL is effective for understanding as it is the brain's natural activity.

The study also showed that there was no significant difference among students in terms of academic achievement in the Mathematics when taught by using Brain-Based Learning method in terms of gender. There was no significant difference between the performance of male and female students in the instructional approach. This result suggests that BBL is a gender-friendly and an equal opportunity system for learning. The results of this study are similar to Bilal (2010) which found no significant difference in achievement between learners with various learner characteristics who were exposed to Brain Based Learning. The result is also congruent with the Brain-Based learning approach, which prioritizes the learners, irrespective of gender differences (Gladys et al. ,2018) and (Koşar, & Bedir, 2018).

The findings also indicated that when teaching students with Brain Based Learning, there was no significant effect of school location on students' academic achievement in Mathematics. This means that the students from rural and urban areas equally gained from the teaching method. The findings indicate that Brain Based Learning has an impact in various school settings and learning environments. This is echoed by the stance of Amjad, et al. (2022) that Brain Based Learning provides an environment which is learner-friendly, non-threatening, and increases students' understanding regardless of context and background. This finding also corroborates the findings of Aaron A. et al. (2023) who found no significant difference in the effectiveness of BBL in various academic settings and disciplines through moderator analysis.

### **Conclusion**

The study concluded that the achievement of the students in Mathematics and their conceptual understanding obtained using the Brain Based Learning (BBL) instructional approach were significantly higher than those obtained using the conventional teaching approach. The study established that BBL is learner-centred and brain-friendly that improved



the students' engagement, understanding and performance in Mathematics. The study also found that gender and location of the school did not significantly impact the achievement of the students when delivered by Brain Based Learning instructional approach. This implies that BBL is effective for both male and female students as well as students from rural and urban schools. Thus, Brain Based Learning instructional approach is an effective and inclusive instructional strategy to enhance students' concepts of Mathematics in Junior Secondary School students in Ekiti State.

### Recommendations

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

1. Mathematics teachers should use Brain-Based Learning approach in their teaching to improve students' conceptual understanding and academic performance.
2. The Government and the Educational stakeholders should arrange seminars, workshop and In-service training programmes for the Mathematics teachers on effective use of Brain Based learning instructional strategies in classroom.
3. Brain Based Learning activities and learner-centred instructional strategies should be integrated into Mathematics curriculum and instructional materials for curriculum planning and writing.
4. School administrators should create an environment in the classroom that is conducive and learning friendly in support of the implementation of the Brain Based Learning instructional approach.
5. Further studies should be carried out on the application of Brain-Based Learning instructional approach in Mathematics topics at different levels of education.

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