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EFFECT OF BALL-AND-STICK MODEL INSTRUCTIONAL STRATEGY ON SENIOR SECONDARY SCHOOL II STUDENTS' INTEREST AND PERFORMANCE IN STEREOCHEMISTRY IN TARABA STATE

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ABSTRACT

This study determined the effect of ball-and-stick model on senior secondary school II students' interest and performance in stereochemistry in Taraba State, Nigeria. The population of the study consisted of 530 senior secondary school two students in twenty secondary schools in Bali Education Zone. Quasi-experimental design of pre-test post-test was adopted for this study. Intact classes in the schools were assigned to experimental group (Ball-and-Stick Model) and Control Group (Expository Method). The sampling of schools was based on simple random sampling technique by balloting with the numbers of students in the experimental group thirty-five 35 and forty-five students in the control group. The validity of the Instruments was determined by chemistry education Experts. The instruments Stereochemistry Performance Test (SPT) and Stereochemistry Interest Inventory (SII) reliability determined using Kuder Richardson 21 coefficient 0.81 and Cronbach Alpha coefficient 0.79 respectively were used. The method for data collection administered was pre-test administered for forty minutes using the instrument SPT and SII scores were recorded after the treatment for four weeks post-test was administered and data were collected using the same instrument SPT and SII scores recorded. Data collected were analyzed using mean, standard deviation to answered the Research Question and t-test was used to answer the Research Hypotheses at 0.05 level of significance. The results indicated that a significance difference exists between students taught stereochemistry using ball-and-stick model and those taught using expository method. It is recommended that used of ball-and-stick model and relevancy of the teaching materials should be put to practice by teachers in order to bring forth understanding in the concept and that Government and Proprietors should ensure the provision of ball-and-stick model in schools.

Keywords: ball-and-stick model; expository method, stereochemistry; interest , academic performance.

INTRODUCTION

Chemistry a subject taught in Nigerian senior secondary school as one of the science subjects that is indispensable driven force for the technological advancement of any nation. Students' needs understanding of the various concepts in chemistry as it relates to the physical and chemical properties of matter needed to actualized the understanding of the natural phenomenon.

Development in science and technology have greatly affected human beings and to be ignorant of this development is to live imaginary life. The development in technology of any Nation greatly depends on the advancement of science, this can be justified from the admission ratio of 60:40 of science and science related courses to the Arts and Humanity into Nigerian Higher institutions (FRN, 2014).In strive to achieve National development, Federal government give mandate to the federal ministry of education, Federal ministry of science and technology, National Communication commission and her subsidiaries the universal service provision funds to provide needed support to schools as well as provision of instructional materials (FRN,2014).

In actualizing the above, the universal service provision funds provide computers, software and shortwave broadband to one thousand two hundred (1200) Secondary schools across Nigeria (FRN, 2016). One of reasons for the provision of these facilities is to make teaching and learning easier and to reduce the problems faced by teachers and for continues professional development of teachers, the provision of learning facilities by universal basic education and tertiary education funds to reduce the problems such as: lack or inadequate laboratories facilities, poor or inappropriate used of instructional materials in schools. In all these efforts, there were significance improvement in the general performance of students in 2019 WAEC science subjects compared to the previous year's 2018 (WAEC, 2019). However, the performance of students in chemistry were low compared to the other years.

Table1: Students' Performance in Chemistry

Year	Mean	SD	Student sat for Exams
2015	36.0	15.62	619,407
2016	43.0	15.36	667,412
2017	47.0	16.0	704,494
2018	29.0	13.78	728,998
2019	40.0	14.46	762,595

Source: waeconline.org.ng

Chemistry is a branch of science that deal with composition properties and the uses of matter. Chemistry explain how substance are form, how the atoms elements combine or break up and how atoms and compounds react under different conditions. The importance of chemistry cannot be underscored because applied science degree such as medicine. Agriculture, Engineering, Geology, Biochemistry, and Biology in any institution of learning in the world required knowledge of chemistry. The candidate must have passed chemistry in the School Certificate Examination or equivalent and Unified Tertiary Matriculation Examination to be qualify for admission into any Universities in Nigeria (UTME, 2019). Chemistry as a science subject can be felt in all aspect of humanity (Diovu, 2012). The chemist can be employed in industries such as

cement industries, food industries, breweries industries, drugs industries, oil industries, refineries and government establishment such as ministries of defense, ministry of environment, ministries of education, ministries of science and technology, ministries of agriculture, forensic studies and space studies.

Instructional materials are those materials used for teaching whose production and usage are activity based, students centered, interesting, stimulating and innovative and are capable of creating interest. Such materials include ball-and–stick model (Diovu, 2012). It is important to find out the effect of ball-and-stick model on students' academic performance and interest in stereochemistry in secondary school. It is against this background that the present study sought to investigate the effects of ball-and-stick model on academic performance, gender and interest of SSII students in stereochemistry.

There is a general concern among stakeholders and educators especially chemical educators over the performance of students in senior secondary school chemistry. One of the major aspects of chemistry in senior secondary school curriculum that faced serious challenges over the years as indicated by the West African examination council chief examiner report (WAEC, 2019) is the poor performance in organic chemistry questions due to inappropriate instructional techniques, teacher Centre method, lack of students' active participation among others. According to the chief examiner report of the West African examination (WAEC, 2018) there were low numbers of students that attempted organic chemistry questions and their performance were very poor compared to the students that's attempted other chemistry questions. They also reported that candidates concentrated mainly on familiar questions that demanded recall of facts and were unable to apply their knowledge of scientific principle to answer other question. Other areas of weakness according to the Chief Examiner Report (WAEC, 2019) are poor mathematical skill, inability to write chemical formula correctly, poor spelling and poor understanding of the structure, inaccurate nomenclature and properties of organic compounds. They further reported that the candidates answered organic questions poorly, even those who answer the question failed to draw correct structures and give correct international union of pure and applied chemistry (IUPAC) names of organic compounds. The chief examiners recommends that, the candidate could perform better if innovative instructional materials such as stereochemistry model (ball-and-stick-model) are used in teaching them. Therefore, the problem of the study is to investigate the effect of ball-and-stick model on students' interest and performance in stereochemistry in senior secondary school students in Taraba State.

THEORETICAL FRAMEWORK

This review focused on learning theories that have attempted to establish theory about knowledge, cognitive abilities, and inquiry in the teaching – learning process.

Therefore, this research is anchored on the cognitive field theory of learning (Gestalt psychology). This theory is sufficiently developed to demand consideration from one seriously interested i problem solving in cognitive field theory originated by some German psychologists; Max Wertheimer, Kurt-Koffka and Wolfgang Kohler who were interested in developing a new approach to behavior, which came to be known as 'Gestalt psychology' (Noel and Smith, 2002).

Chauhan,Mc Mahon and Bredo in Diovu (2012) indicates that the main factor in Gestalt psychology is the development of insight. The individual and his environment form a psychological field. According to the Gestalt psychology, the perception of the field and the gradual restructuring of the field is known as 'insight'. According to Kurt Lewin as stated in Mc Mahon and Mc Mahon (1991), insight is a process of structuring or restructuring of a perceived area. The concept of insight is, therefore, accorded a central role and employed in the Gestalt psychology.

Some literature reviewed attempted some descriptions of situations, which result to insight or insightful learning. When an individual struggles with a problem, the solution may come to him all of a sudden (Chauhan, 1987). This quick change in our perception is called an insight. Chauhan (1987) identified some characteristics of insightful learning as follows; survey of problematic situation, hesitation; pause, attitude or trail or a mode of response; trial of other responses in case initial mode of response proved inadequate.

The transition from one method to the other is always sharp and often sudden. According to Chauhan, (1987), Mc Mahon and Mc Mahon (1991) as cited by Diovu (2012) the conclusions drawn on several experiments conducted on insightful learning are as follows:

Small children are usually better able to perceive essential relations when they are given concrete materials. They have limited capacity to manipulate, examine and draw conclusions about objects or events not directly present before them. At high intellectual levels, the students are partially free from their dependence on concrete materials usually before them. The structure and organization of the subject matter plays an important role in learning. The teacher should encourage the students to search the materials to develop insight. He must help the learners to perceive the goal and the intervening variables.

The application of models in teaching and learning organic chemistry manifests the main factors in Gestalt psychology. In used of models the expected specifications is manipulating the models in the teaching-learning process, the students tend to apply creativity, this study is based on the Gestalt Theory and it principles on similarity, continuation, closure, proximity and figure-ground. Ball-and-stick model is a molecular model method used to show the shape of molecule following the Gestalt principles, the ball-and-stick models help better understand how each atom is connected in a molecule and it show relative bond length and bond angle.

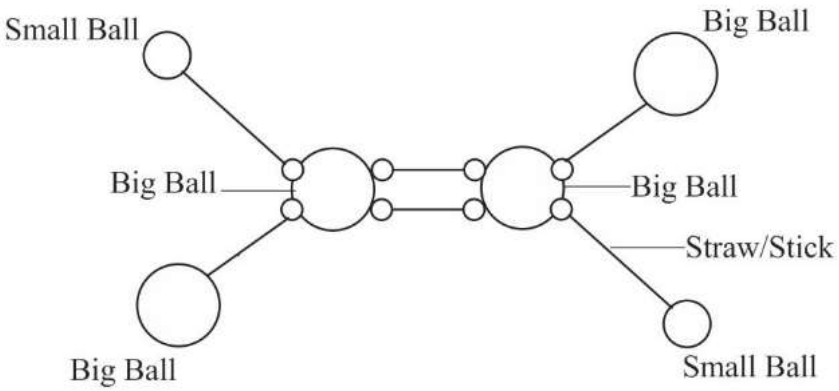
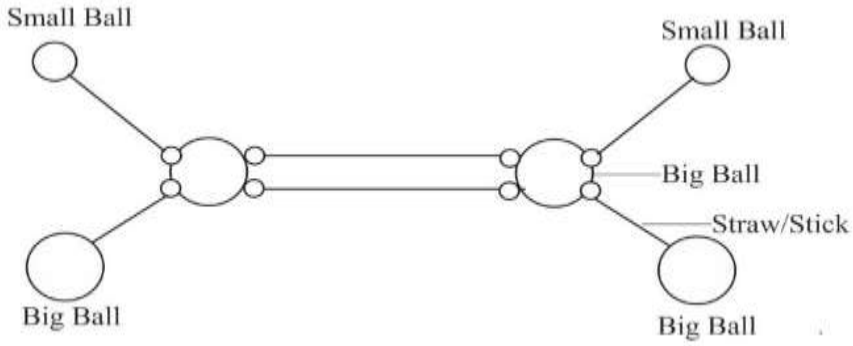


Figure 1: Ball-and-stick Model (a) trans-



(b) cis-

Jerome S. Bruner, a great American Cognitive Psychologist is of the view that learning is effectively engaged in if the learner is given the opportunity to discover facts by himself. Bruner argues that mere presentation of information will not enhance effective solution of a problem. He views the mere presentation of information as a means of helping the learner to remember facts but he is not assisted to use it for the solution of day-to-day problem. Bruner in Diovu (2012) suggests that teachers should create situations that would help the learners to discover facts by themselves. In this case, the teacher should establish an explorative environment for the learners to explore facts and discover the facts or truth by themselves. According to him, prepackaged information can lead only to rote memorization of facts. He then contends that rote memorization is of no substantial benefit in the exploration of the environment and the solution of the problem. Bruner is of the view that human cognition develops as the individual interacts with the environment and explores it. According to Bruner, the individual acquires information through his interaction with the environment. Bandura (2011) stressed that information is much retained and utilized for the solution of the environmental problems. Following Bruner's theory, involving the students to use the models that can exposes the students to interacting with the environment, exploring it and finding solutions to the problems they have in organic chemistry. The use of stereochemistry models for teaching them is in line with Bruner's theory of discovery learning models to explore and interact with their environment.

THE CHEMISTRY CURRICULUM AT SSCE LEVEL

Curriculum has been defined variously by various scholars depending on their interpretation of education and the various functions schools should perform to the individual and to the society at large. Curriculum is the experience a school system provides for its students. Curriculum according to Offorma (2009) is defined as the "document, plan or desirable learner's behavioral changes". Curriculum is the roadmap of teaching and learning. It becomes relevant if it addresses current and anticipated needs, problems and aspirations of the learner and his/her society (Okoli, and Egbunonu, 2011).

The revised edition of the senior secondary school chemistry curriculum is expected among other things to enable students to:

(i) Develop interest in the subject of chemistry
(ii) Acquire basic theoretical and practical knowledge and skills
(iii) Develop interest in science, technology and mathematics (STM)

(iv) Acquire basic STM knowledge and skills
(v) Apply skills to meet societal needs of creating employment and wealth (FME,2009).

The chemistry curriculum contents is divided into four themes:
(i) The chemical world
(ii) Chemistry and environment
(iii) Chemistry and industry
(iv) Chemistry for life

The chemistry curriculum theme presented under the following headings:
Topic
Performance objectives
Contents
Activities
Teaching and Learning Materials
Evaluation Guide

Chemistry curriculum packaged with content that leads to self-actualization by students on practical activity with emphasis on locally available materials and view that the four contents pass across all the three arms of SSII, SSII, and SSIII of the senior secondary school.

THE PLACE OF ORGANIC CHEMISTRY IN THE SSCE CHEMISTRY CURRICULUM

The senior secondary school chemistry curriculum consists of organic chemistry, inorganic chemistry and physical chemistry topics. The theme of organic and its contents had been placed as the fourth theme to be covered in every classes of senior secondary school in Nigeria. There are 39 topics in the chemistry curriculum for senior secondary school in Nigeria with 10.25% contents of organic chemistry, Organic chemistry topics in senior secondary school two had 5.13% contents compared with senior secondary one and senior secondary three with the percentage of 2.56% content each.

The chemistry for life in Senior Secondary one as a theme contains the topic carbon and its compounds, in Senior Secondary three the theme contains a topic hydrocarbon stipulate the use of model of hydrocarbon as one of the teaching and learning material to be use in organic chemistry classes.

In senior secondary school SSSIII, the chemistry curriculum under the theme for chemistry of life has a topic Giant Molecules.

All the topic in organic chemistry have been placed under the theme chemistry of life consist of teacher and students' activities, teachers' activity are what teacher do in the class while delivery the content to the students. The students' activities are those activities that students perform during the lesson at a particular time.

The curriculum also consists of the performance objective, students are expected to be able to perform at the end of a lesson. The chemistry curriculum further contains an evaluation guide to effectively evaluate the performance objective of the lesson under the study.

The organic chemistry contents have been placed as the fourth theme in the senior secondary school chemistry curriculum, chemistry for life placed as the last theme in chemistry curriculum for each class (FME, 2009)

The theme chemistry of life in chemistry curriculum for senior secondary school advocate the use of stereochemistry model as learning materials in chemical education (NERDC, 2009).
The organic chemistry theme presented under the following headings:
Topic, Performance objectives, Contents, Activities, Teaching and Learning Materials and Evaluation Guide.
Also, secondary school chemistry curriculum calls for the use of stereochemistry models of hydrocarbon for teaching organic chemistry in senior secondary school and the use of chart and the colored breed were also stress as learning materials (FME, 2009)

RESEARCH QUESTIONS

The study was guided by the following research questions:

1. What is the mean interest scores of students taught stereochemistry using ball-and-stick model and those taught with expository method?
2. What is the mean academic performance scores of students taught stereochemistry using ball-and-stick model and those taught using expository method?

RESEARCH HYPOTHESES

The following null hypotheses were formulated and tested in the study:
Ho1: There is no significant difference in mean interest scores between students taught stereochemistry using ball-and-stick model and those taught using expository method.
Ho2: There is no significant difference in the mean academic performance scores between students taught stereochemistry using ball-and-stick model and those taught using expository method.

RESEARCH DESIGN

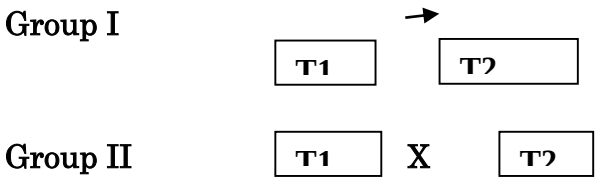
The researcher adopted quasi-experimental design for the study. The pre-test, post-test non-equivalent, control group design was used. Quasi-experimental are experiments to be use when a researcher cannot use random assignment of subjects or group (Nworgu, 2006). Intact classes were used and the classes were assigned in to experimental and control group. The design was chosen because the subjects for the study can be manipulated.

MATERIALS AND METHODS

Experimental group

Materials used for the study consist of Stereochemistry Learning Material, Stereochemistry Lesson Plan, the treatment was teaching the students using the Stereochemistry Learning Materials (SLM) for the duration of four weeks. Four experimental lessons were carryout on topics: alkane, alkene, alkyne isomerism and Nomenclatures in stereochemistry.
Procedure: The teacher distributed the SLM to the students. Each student will carry out requires activity as contain in the SLM. The pre-test would be to test students' background level, in other to determine whether the students are academically the same before the experiment, students thereafter carry out the learning activities expected of them on individual bases. When taught with SLM, each student was engaged to test their understanding of the learning material. They

proceeded to post-test administered at the end of four weeks lesson as they answer the test correctly. At the end of the four weeks treatment, post-test was administered to the students and scores were recorded. After the treatment, scores on the interest and performance scores of the participant were recorded, this is the post test scores measured The experimental group was taught using ball-and-stick model and the control group was taught using expository method.
The research methods design following two group.



T1=Test before treatment
T2 = Test after treatment
X = Learning treatment using ball-and-stick model
Learning treatment using Expository method
The pre-test was first administered to the students. The researcher thereafter taught them lesson using the Expository method. The students were given assignments which the teacher went through the corrections with them. At the end of the four weeks duration, the post-test was administered to the students and scores were recorded.

AREA OF STUDY

This study was conducted in Bali Educational Zone which is one of the three Educational Zone in Taraba State Central Zone, Nigeria. The Bali zone is made up of two local government areas with twenty (20) public senior secondary schools that offers chemistry at SSCE level. The names of the local governments with numbers of school are as follows: Bali local government has 14 schools and Gashaka local government has six (6) schools. The zone was selected for the study because the schools are homogeneous and are under the same education authority. Also, for easy access and convenience for effective management of the available financial resources meant for the study. This is because the researcher had ensured their agreement with the stipulating plan of the study by visiting the sample schools regularly during the period of the study.

POPULATION OF THE STUDY

The target population consists of **530** senior secondary two chemistry students in twenty schools in Bali Educational zone in the 2020/2021 academic session. This level of students was chosen because stereochemistry topic found in Chemistry Curriculum.

SAMPLE AND SAMPLING TECHNIQUE

Intact classes in the schools were assigned to experimental group (ball-and-stick model) and control group (expository method). The sampling of schools was based on simple random sampling technique by balloting.

INSTRUMENT FOR DATA COLLECTION

The instruments that were used for data collection in this study is Stereochemistry Performance Test (SPT) and Stereochemistry Interest Inventory (SII). The instruments Stereochemistry Performance Test (SPT) and Stereochemistry Interest Inventory (SII) was developed by the researcher. The SPT comprise of 25 multiple-choice test items drawn from the chemistry topics stereochemistry in SSII as contained in their curriculum for senior secondary schools, the researcher developed the table of specification for content validity to determine the number of test items for each topic across the objective namely; knowledge (remembering), comprehension (understanding) and application (thinking). Each test item has four responses options A-D with only one option as the correct answer.

VALIDATION OF THE INSTRUMENTS

The SPT was subjected to content validity by the researcher through the development of the table of specification for content validity to determine the number of test items for each topic across the objectives to ensured and appropriate distribution of the test items with respect to the relevant contents' areas chosen as well as the cognitive objective level desired the SPT is a twenty-five items four option multiple choice test instrument based on five content areas for the study. The five contents areas for this study are stated on the table of specification. The weighing for the objective level was based on the proportion of low order performance and high-performance objectives in the units of study in the SSII chemistry curriculum (FME,2009). The number of weeks each topic last in the scheme of work for secondary school in Taraba State formed the bases for weighting of the contents. The instrument was ensured to satisfies all the psychometric properties; the researcher developed the total of thirty test items based on the content that stereochemistry can be used for teaching within each topic selected for the study. The items were later re-organized into a total of twenty-five items. Subject Master Experts (SME) subjected the remaining items to criticism and vetting as requested by the researcher following the criteria with respect to objective, relevance content, repetition and other criticism and faced validation by the two experts are principal education officer taught chemistry in senior secondary school for more than ten years as the chemistry curriculum implementors in Government Secondary School, Bali and International Secondary School Abubakar Tafawa Balewa University. Specifically, the test items of the SPT were modified and adjusted according to the expert's comments.

The researcher assembled ten statements on stereochemistry through review of relevant literature. The researcher requested chemistry students to write out some statements they like about stereochemistry, as well as some statements they do not like about stereochemistry. The researcher collates these statements and others from relevant literature, and assemble positive and negative interest statements on stereochemistry. The researcher subjected these statements to a closer scrutiny thereby resulting in necessary sorting-out, re-organization and re-assembling of the items. The ten (10) items were prepared in the form of a questionnaire using a five (5) point Likert scale. The instruments Stereochemistry Inventory Test questionnaire was given to two experts in measurement and evaluation and one in education chemistry for validation. The experts were requested to rate the suitability of each of the items

of the instrument on the five-point rating scale provided of the expression, with the most negative statement rate 1to 5 and the most positive statement rate 5 to 1.
In addition, lesson plan was prepared by the researcher for teaching stereochemistry for the ball-and-stick model group and expository method group.

RELIABILITY OF THE INSTRUMENTS

The reliability of the Stereochemistry Performance Test instrument was determined using the Kuder Richardson formula 21 which was found to be 0.81 of the test items instrument. This form of reliability was considered appropriate for the instruments that have items that are dichotomously scored such as SPT.
The reliability coefficient of the Stereochemistry Interest Inventory (SII) was determined using the Cronbach's Alpha. The Cronbach's Alpha gives an estimate of the test instrument (SII,) alpha value of 0.79 scores of more than 0.7 is usually okay (Salkind, 2015). The Cronbach's Alpha was considered suitable because the items of the instrument were not dichotomously scored.

METHOD OF DATA COLLECTION

The permission of school authority was obtained, researcher organized a two days' training for the regular formalization of the sample school's researcher administered pretest to the school for period of 40minutes collected the script mark and recorded their scores. In other not to altered classed time-table, the lesson followed their usual class period and broad topic was covered in a week for a period of four lesson every week. The researcher administers the posttest for a period of 40minute, mark and recorded their scores

RESULTS

Research Question 1:

What is the effect mean interest scores of students taught stereochemistry using ball- and sticks model and those using expository method?
Table 2: indicated that the difference between the mean interests of the students taught stereochemistry of post-test in experimental and control groups. The mean interest of the students taught stereochemistry of post-test in experimental is 40.36 against the standard deviation of 5.505 and the mean interest of the students taught stereochemistry of post-test in control group is 35.36 against standard deviation of 4.140 respectively. Therefore, the difference of the mean scores of 5.46 is obtained. This depicts that, there is great difference significant between post-test mean interest of experimental and control groups in favor of experimental groups.

Table 2: Post-test Mean Interest Scores of Students Taught Stereochemistry using Ball-and-Stick Model and those taught using Expository Method

Group	N	Mean	SD	Mean Difference
Experimental	35	40.36	5.505	5.00
Control	45	35.36	4.140	
Total	80			

Research Question 2:

What is the difference in the mean academic performance between students taught stereochemistry using ball-and-stick model and those taught using expository method?

Table 3 indicated that the difference between the average mean scores of post-tests of experimental and control group of the academic performance of students is 24.11 against the standard deviation of 3.179 and 22.07 against standard deviation of 2.250 respectively. Therefore, the difference of the mean score of 2.04 is obtained. This depicts that, there is significant difference between post-test mean scores of experimental and control groups in favor of experimental groups.

Table 3: Post-test Mean Academic Performance Scores of Students Taught Stereochemistry using Ball-Stick Model and those Taught Using Expository Methods.

Group	N	Mean	SD	Mean Difference
Experimental	35	24.11	3.179	
				2.04
Control	45	22.07	2.250	
Total	80			

Research Hypothesis 1: there is no significant difference between the mean interest scores of students taught stereochemistry using ball –and stick model and expository method in favor of ball –and stick model.

Table 4 shows the t-test comparison between the interest of students in experimental group taught stereochemistry using ball –and stick model and control group taught expository method. The mean interest of experimental group is 40.82 against standard deviation of 5.565 while mean interest that of control group is 35.36 against standard deviation of 4.140 respectively. The t-value was found to be 5.287 against p-value of 0.000 at degree of freedom (df) 78. Conclusively, the result shows that, there is significant difference between the mean interest scores of students taught stereochemistry using ball –and stick model and expository method in favor of ball –and stick model. Therefore, the null hypothesis was rejected against the alternative.

Table 4: Summary of Independent Sample t-test on the Effect of Ball –and -Stick Model and Expository Method on Students' Academic Performance in Stereochemistry.

Group	N	Mean	SD	Mean Difference	Df	t –cal	Sig.	Decision
EXP	35	40.82	5.565					
COT	45	35.36	4.140	.5.46	88	5.287	.000	HO_1 is
Total	80							Rejected

Research Hypothesis 2: there is no significant difference between the mean academic performance of students taught stereochemistry using ball –and stick model and expository method in favor of ball –and stick model.

shows the independent t-test comparison between the academic performance of students in experimental group taught stereochemistry using ball –and stick model and control group taught expository method. The academic performance of students in experimental group is 23.67 against standard deviation of 3.038 while academic performance of students in control group is 22.08 against standard deviation of 2.370 respectively. The t-value was found to be 2.579 against p-value of 0.012 at degree of freedom (df) 78. Conclusively, the result shows that, there is significant difference between the academic performances of students taught stereochemistry using ball –and stick model and expository method in favor of ball –and stick model. Therefore, the null hypothesis was rejected against the alternative.

Table 5: Summary of Independent Sample t-test on the effect of ball –and stick model and Expository Method on Academic Performance of Students taught stereochemistry.

Group	N	Mean	SD	Mean Difference	Df	t-cal	Sig.	Decision
EXP	35	23.67	3.038					
COT	45	22.08	2.370	1.610	78	2.579	.012	HO_3 is Rejected
Total	80							

CONCLUSION

In conclusion, students in ball-and-stick model group perceived to higher interest scores in the study than students in expository method group and a significant increase in the academic performance of students in ball-and-stick model is higher compared to expository method group. Implicatively, stereochemistry topics in senior secondary school in Nigeria would be better understands if ball-and-stick model is put to practice.

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