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Validity of Brainstorming Strategy on Students' Prior Knowledge and Academic Performance in Chemistry in Selected Secondary Schools in South-South Nigeria

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Abstract

This study examined the effects of brainstorming strategy on students' prior knowledge and academic performance in chemistry. A sample of 148 participants (made up of 71 female and 77 male students) in their intact classes were drawn from four selected coeducational secondary schools in two states in south-south Nigeria. The schools were assigned into two instructional groups- the experimental (brainstorming strategy) group with 73 and control (lecture method) group with 75 students. Data were obtained through the administration of Pretest followed with a seven week treatment, and then the administration of posttest. Data were analyzed using mean and analysis of covariance (ANCOVA). Results showed statistically significant difference in both mean knowledge and mean academic performance in favour of the brainstorming group. The result further showed no statistically significant difference in the mean academic performance of male and female students in the experimental group. More so, the study revealed no significant interaction effect of instructional strategies and sex on academic performance.

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From the results of this study it was recommended that science curriculum designers and teachers should respectively design and use appropriate instructional strategies and packages that can evoke students' prior knowledge to promote learning.

Keywords: Academic performance; Chemistry; Brainstorming strategy; Prior knowledge.

1. Introduction

In this era of technological explosion and advancement driven by science and technology, we cannot deny the assuming, conspicuous and multi-dimensional impacts of science and technology on every facet of lives as well as our nation. Everyone, from the so-called little or poor man on the street to the very rich or highly placed individuals in the society is in one way or the other at ease with the importance of science. Following the relevance and globalization of science, no country wants to lag behind in scientific and technological development. And so, countries try to pay attention to science education with the utmost aim of training up her citizens so as to acquire the needed manpower (scientists, nurses, technologists, doctors, engineers, science educators, among others) who in their different fields can contribute meaningfully to the scientific and technological development of their nations [14]. To achieve this requires effective teaching and learning of science in our schools.

Among the three pure science subjects (chemistry, biology and physics) at the secondary school level, chemistry (i.e. the study of matter and its composition, characteristics, reactions and uses) is the central science because of its relationship with (and importance to) other pure sciences and science related disciplines. Chemistry is very important for our daily living in this science and technological age following its applications in industries, homes, agriculture, medicines, water treatment and in several other fields.

One aspect of chemistry is stoichiometry. It is the quantitative aspect of chemistry involving the use of mole concept, correct chemical symbol and formula of substances involved in a chemical reaction, and a balanced chemical equation of the reaction to uncover the amount of atom(s) in a given compound, as well as the amount of atom(s) and molecule(s) of reactants and products of a chemical reaction; and is based on the laws of chemical combination.

Stoichiometry is the study of the relationship between the quantities (mass, mole or volume) of substances in a given substance, as well as the relationships between quantities of substances (reactants and products) taking part in a chemical change. Brown, Reference [13] defined stroichiometry as the study of the quantitative aspect of the mass-mole number relationship, chemical formulas, and chemical reactions. The knowledge of stoichiometry is very important to every person, mostly those in the sciences and manufacturing sector, in helping them to know the amount of reactant(s) consumed or product formed, and the amount of excess and limiting reagents taking part in chemical reactions.

Poor performance of students in chemistry has been reported to be related to students' poor background knowledge or prior knowledge [1, 34], Poor teaching methods [1], Akinola, 2006 cited in [7] ; abstract nature of some contents / concepts of the subject [30], Ezeliora, 2000 and Taber, 2002 cited in [7]; some difficult concepts

[28]. More so, research has revealed that students' poor performance in chemistry is due to their inability to solve problem in stoichiometry [37, 49], perception of calculations relating to stoichiometry as difficult and demanding [16, 22] while some exhibit surface learning approach in learning stoichiometry [21] among others. In the midst of these factors, the teaching method seems to be more associated with the poor performance of students because it is the responsibility of teachers as facilitators of learning to adopt teaching strategies that can actively engage students in learning. One of such strategies is the constructivist approach which lay emphasis on the active role of the learner in constructing knowledge as well as making sense of information. According to [38], constructivism is a theory that believes in human generation of knowledge and meaning from the interaction between their experience and ideas.

The constructivist approach to teaching stresses on meaningful learning and knowledge building through two processes: 1).The learners' internal (cognitive) process. In this process, new knowledge is derived from previous knowledge by the transformation, organization and reorganization of previous knowledge. (2).The interaction between both the learners' internal and external processes. Here new knowledge is constructed as a consequence of the relationship or interaction between cognitive experience or prior knowledge and the external (i.e. environmental or social) factors. The external or social factor here can be in the form of social interactions with knowledgeable adults or peers who render help or scaffolding. During scaffolding, previous knowledge is activated. In any of these processes, prior knowledge is required for meaningful learning to take place.

Brainstorming as one of the constructivist techniques was originally introduced by an American advertizing executive, Alex Osborn [39, 40] as a technique of generating ideas from a group of people in an attempt to solve a problem. He established this strategy when he realized that the traditional modes of business meetings were unable to create new ideas. He also proposed the following four rules for effective brainstorming:
(i).No criticism of ideas: During brainstorming, judgment or criticism of ideas is excluded until the end of the session.
(ii).Encouraging large quantities of ideas: Quantity of ideas is the major goal of brainstorming. The more ideas the group or participants generate, the more the chance of having good ideas among them.
(iii).Building on each other's ideas: Combination and improvement of ideas are very necessary. Participants should be very free to associate, build and elaborate their own ideas based on ideas from others.
(iv).Encourage every idea: Take every idea (both silly and intelligent ones) as valid, and encourage the participants to share their ideas.

Brainstorming can be viewed as a technique in which an individual or a group engages in critical thinking to generate wide-ranging ideas toward solving a problem. This strategy is now widely applied in different fields of human endeavour including education.

With regard to brainstorming and academic performance, studies [2, 3, 4, 5, 8, 18, 23, 27, 31, 44] have revealed the relevance of brainstorming in promoting the learning of school subjects, creative thinking and critical thinking as well as academic achievement. For example, Mohammad [31] applied a quasi-experimental (pretest-posttest) approach to study the effect of brainstorming strategy in Balqi Applied University's students' achievement in the course 'E 101' using a randomly selected sample of 68 students distributed into two groups viz: experimental group, n= 34 and control group, n=34. The experimental group received instructions through brainstorming strategy while the control group did not. And by measuring the participants' achievement through the administration of achievement exam, results of the study showed that (i) there was a significant difference in students' achievement between the two groups in favour of the experimental group taught via brainstorming strategy, (ii) there was a significant difference in mean achievement score of male and female students in favour of the female (iii) there was no significant differences in students' achievement in the two groups with regards to interaction effect of gender and methods of teaching.

In a study to explore the effect of brainstorming as pre-writing strategy on English as a Foreign Language (EFL) advanced learner's ability in Iran, Reference [23] divided a sample of sixty (60) Persian native speakers into two groups- experimental group (32 students made up 14 males and 18 females) and control group (28 students comprising 13 males and 15 females). Results of the study revealed that the experimental group that received instructions following brainstorming strategy performed significantly better than the control group. But no significant difference in brainstorming and its sub-categories (listing, outlining, question and answer) with respect to gender. In another study, Reference [8] investigated the effectiveness of brainstorming in teaching social study and found a statistically significant difference in the mean performance between the experimental group and the control group in both total score of the test and its sub skills.

Reference [2] used a sample of 100 male and female students from two public schools (one male school and the other female) in Tabouk to investigate the effectiveness of brainstorming in developing creative thinking; and found a statistically significant difference in favour of the group attributed to the teaching of creative thinking through brainstorming. The result also showed no significant difference between the means of males and females performance, as well as in the interaction between the method and gender. In a pretest – posttest control group (quasi-experimental) design study, Reference [4] identify the effectiveness of using brainstorming technique to learn some basic skills and knowledge for beginners in volleyball. He used a sample of 50 first year students of the faculty of Physical Education, Beha University for the 2011/2012 academic session. The experimental group was exposed to 7 week educational programmes (teaching) based on brainstorming; while the control group received similar educational programmes without brainstorming. And using tests of physical, skills, and achievement of cognitive attainment and intelligence, the results of the study showed that the method of brainstorming had a positive effect on the experimental group in learning skills such as passing, serving and smash stroke. The percentage rate in the level of performance skills and cognitive attainment of basic skills in the sport of volleyball acquired by the experimental group surpass that of the control group.

In the science discipline, Reference [5] conducted a quasi-experimental study on a sample of 85 students to investigate the effect of both brainstorming and discovery strategies in developing creative thinking among eight graders in science in Jordan. Findings of this study showed that both brainstorming and discovery strategies produce effect in developing creative thinking. However, the effect was higher and significant in favour of the group exposed to brainstorming strategy. Again, Reference [48] studied the effect of both brainstorming and computer education instructional strategies on the academic achievement and the development of critical thinking skills of sixth grades, and their attitudes towards the learning of mathematics. The researcher adopted a quasi-experimental design and a study sample of 69 students spread into two groups- the brainstorming strategy group with 34 students and the computer education strategy group with 35 students. The result of the study indicated a statistically significant difference in both the mean academic achievement scores and the creative thinking skills between the two groups in favour of the group taught through brainstorming.

Reference [35] employed a non-randomized control group pretest, post-test quasi experimental design to study the effects of brainstorming on the academic achievement of senior secondary chemistry students in Benue State, Nigeria. In the study, a sample of 156 senior secondary two (i.e. SS 2) chemistry students drawn from four senior secondary schools in zone B educational area of the state participated in the Results study. of the study indicated a significant difference in the mean achievement in favour of the brainstorming group. In addition, the study also showed that the mean difference between male and female students exposed to brainstorming is significant in favour of the male students as they had higher mean than the female students; urban male exposed to brainstorming achieved significantly higher than their rural colleagues exposed to brainstorming. The study of Reference [3] on the impact of brainstorming in the development of critical thinking and academic achievement among first secondary school students in Biology in Array City, Saudi Arabia used a sample of 63 students divided into experimental and control groups. The result revealed the presence of statistically significant difference in the average achievement of students in the two groups in favour of the experimental group which studied by using brainstorming.

Prior knowledge is interchangeably used with background knowledge, existing knowledge or previous knowledge all portraying the same idea. Reference [15] conceived prior knowledge as the totality of an individual knowledge including those of explicit and tacit knowledge, metacognitive and conceptual knowledge. To Strangeman and Hill (2005) cited in [51], prior knowledge is a general term which encompasses more specific knowledge dimensions such as metacognitive, personal or self-knowledge subject matter, and conceptual knowledge. Background knowledge or prior knowledge is what an individual (or a person) already knows about a given thing, content or topic. It can be regarded as the knowledge repertoire of the learner that is related to (and capable of promoting the learning of) new knowledge. It is the foundation knowledge upon which new knowledge is built.

Several studies [12, 19, 29, 46] have documented the logical connection of prior knowledge with a learners' learning outcome. Reference [19] studied the effect of prior knowledge on the achievement of students in chemistry and found no significant difference in the mean prior knowledge between the experimental group and control group as well as in the mean achievement score between male and female students in the experimental group. In the study, the researchers adopted quasi-experimental design (with pre-test, post-test control groups), a sample of 93 SS 2 students drawn from two purposely chosen secondary schools in Dutsin-Ma, Katsina State, and also used the researcher made prior knowledge questionnaire {PKQ) and chemistry achievement test (CAT) as research instruments. The study which lasted for a period of 4 weeks had the experimental group taught through student-teacher interactive approach.

Rodrigo, Ong, Bringula, Basa, Cruz, and Matsuda, [46] carried out a study to assess the impact of prior knowledge and teaching strategies on learning on a sample of 201 students in a high school in Manila, Philippines to replicate their previous study conducted on 160 students in a high school in Pittsburgh, USA.

Through random sampling, the participants in each of the schools in these two studies were assigned to one of two groups of Simstudents viz, experimental group and control group. While the students in the experimental group were constantly quizzed or prompted to self-explain their decisions on the tutor learning, the control group was not asked to give such self- explanation. On analyzing data obtained from pretest, posttest and delayed test, they found among other things that prior knowledge impact significantly on learning in favour of USA students as they had a higher level of prior knowledge than the Philippines students, ($t_{(142)}$ = -22.25, $p<$ 0.001). In a related study on the effect of prior knowledge in mathematics on learner – interface interactions in a learning by teaching intelligent tutoring system, Reference [12] administered a test of prior knowledge in mathematics as pre-test on one hundred and thirty nine (139) high school students and subsequently engaged them in an hour intervention programme for a period of 3 days in which the participants were made to use the Simstudent, an intellectual teaching system that accompanies learning by teaching model. Afterward, a post-test was administered. Result of the study indicated that prior knowledge exhibited a significant impression on learners' interface interaction with Simstudent.

Reference [29] showed the relevance of existing prior knowledge in the learning of new words in a second language. The study involves a group of 80 Greek children of 8-13 years old who have studied English as a foreign language in Greek schools for an average of three years. The participants were divided into four groups based on their scores in English vocabulary and short term memory tests; and later given a paired-associative learning task which require them to pair English word with pictures (i.e. English picture – word pairs) of objects they may not previously have seen in their studies of English. Findings of the study revealed that children in the high English vocabulary group had 70.5% correct responses on the learning task than the low English vocabulary group with 40.3%. The result further showed that on the short term memory task, the high repetition group had 61.5% and the low repetition group 64.0%. The findings indicated the existence of a strong relationship between the rate of learning of words and the child's prior or existing knowledge of the English Language. Meaning that, in whatever way, the short term memory of a child is good; children prior knowledge was the important variable that enables the children to learn the new word. Shapiro [47] established that prior knowledge has much significant value than reading ability in causing learning to take place. This suggest that a learner with adequate and accurate prior knowledge can easily see similarities or links between what had known and what he wants to know and construct more meaning than one with poor, inadequate or inaccurate prior knowledge.

There have been contentions among researchers on the influence of students' sex or gender on academic performance in chemistry. While some [25, 49] had reported no significant difference, others [9,17,41] found significant differences in the chemistry performance of male and female students.

The above literature review shows that brainstorming enhances students thinking skills, problem solving skills, attitude and academic achievement. But [10] sees what the learner already knows (prior knowledge) as the most important variable influencing learning, and therefore stresses the need to discover it as to teach the learner accordingly. Again, it has been reported elsewhere in this work that poor teaching method and poor prior knowledge are some of the causes of poor students' performance in chemistry, consequently, it is assumed that the use of appropriate teaching method can engage the learner in meaningful learning as well as involving him in thinking and knowledge construction during which he is likely to activate his preexisting knowledge as he may reflect on his past experiences and relate them to the issue at hand. Therefore, this study aims at determining the validity of brainstorming strategy on the prior knowledge and academic performance of students in stoichiometric aspect of chemistry.

1.1 Hypotheses

The following null hypotheses (HO) guided the study:

HO_1: There is no significant difference in mean knowledge gain between experimental group and controlgroup students.

HO_2: The mean score in chemistry performance test of students in the experimental group is not significantly different from that of the control group.

HO_3: There is no significant difference in the mean post test scores between male and female students in the experimental and control groups.

HO_4: There is no significant interaction effect of instructional strategies and sex on students' academic performance.

1.2. Theoretical Framework

This work relies on two theories of learning-Piaget's theory of cognitive development [42, 52] and Ausubel's sumpsumption theory of learning [10].

Piaget's theory lay emphasis on meaning and knowledge contribution. Piaget contend that children are active and motivated learners, and that they can create knowledge and meanings from their experiences and ideas, or from the interaction of both. He also theorizes that children inherit two tendencies (organization and adaptation) that are necessary for thinking and learning. They can organize (i.e. arrange, combine, or recombine or rearrange) their thoughts or behaviour into a scheme, and as well, through social interaction adapt or adjust to the environment. Accordingly, he suggested two basic processes of adaptation- assimilation and accommodation through which knowledge and meanings can be constructed. By assimilation the child relates and integrates the new knowledge, concept or experiences into an existing scheme or framework without altering the scheme, and by accommodation, the child learns new concept by either modifying or reframing an already existing schemes to anchor in the new knowledge or by outright forming a new scheme. Again, Piaget believed that equilibration (the process of seeking for mental or conceptual balance between new experience and already existing schemes) influenced learning. This occur when the learner is in a state between equilibrium and disequilibrium. In the state of equilibrium, the learner can explain a new experience in relation to already existing schemes, whereas in the state of disequilibrium, the learner finds the new experience conflicting and incompatible with the existing scheme. This process promotes cognitive development and restructuring, development of higher and complex thought as well as learning.

Ausubel's theory stresses on meaningful learning. According to this theory, meaningful learning is said to occur when the child (learner) is able to bring in new concepts, knowledge or events into his cognitive (knowledge) structure and relate it to the appropriate element (concept, or knowledge) already existing in a cognitive structure. The emphasis of this theory is on the relationship or interaction between the subsumer (i.e. relevant knowledge that already exist) and the new knowledge to be learned to create meaningful learning.

The above theories identify prior knowledge and experiences as critical elements in learning, and as such form the basis for further knowledge and meaning construction. Furthermore, Piaget included social interactions in the environment as an additional variable for effective learning. Thus, this study assume that students' pre-existing knowledge about any topic or content to be learned before receiving instructions play a very significant influence on the learning of the topic during instructions. It is against this view that the study employs brainstorming as an instructional technique to determine chemistry students' prior knowledge and academic performance.

2. Materials and Methods

2.1. Design

The study adopted a non randomized quasi-experimental design with pre-test, post-test non-equivalent control groups. It is non- randomized because the participants are not randomly assigned into groups rather intact classes were assigned into experimental and control groups.

2.2. Sample

A sample of 148 (consisting of 77 male and 71 female) students partook in the study. The sample was drawn from four purposively selected coeducational senior secondary schools in two states (Edo and Rivers) in South-South, Nigeria. In each of the states, two schools were selected, one assigned to experimental group and the other the control group. In all, the experimental group had 73 students while the control group had 75.

2.3. Instruments

Three researcher made instruments were used for study. They are: Prior Knowledge Test, PKT; Stoichiometric aspect of chemistry performance test, SACPT; and Prior Knowledge activation journal, PKAJ. The PKT contained 25 objective questions (15 multiple choice and 10 fill in the item) on chemical formula, mole concept and balancing of chemical equations.

SACPT contained 40 questions (20 multiple choice and 10 fill in the item objective, and 5 short essay questions) on stoichiometric aspect of chemistry.

PKAJ contains 12 structured probing and cueing questions on writing chemical formula, mole concept, steps in writing and balancing chemical equations.

The content and face validity of the instruments were ascertained by two experts in science education (with chemistry bias). The instruments were trial tested on 30 SS 2 students from non participating schools. The reliability of the instruments (PKT, r = 0.74; PKAJ, r = 0.69 and SACPT, r = 0.81) were obtained through split-half technique and using Pearson Product Moment Correlation method in correlating scores of the two halves to obtain the correlation coefficient of the half test which was then subjected to Spearman-Brown Prophecy formula to obtain the reliability of the whole test.

2.4. Procedure

To collect data for the study, PKT and SACPT were first administered as pretests to participants in both the experimental and control groups.

Students in the experimental group were divided into subgroups of 3-4 students each and exposed to brainstorming based on the following steps:

(i) Introduction of brainstorming rules
(ii) presentation of topic
(iii) Administration of PKAJ to the individual student to fill in as many ideas they believe could be the answers to the given question.
(iv) Group discussion. Members of each group meet together to discuss, screen and define their ideas, combine similar ideas and enter them into the PKAJ for the group.
(v) Evaluation of their ideas. Evaluate the ideas they entered into the group PKAJ by praising them for the correct ones and engaging them to correct the inaccurate ones.
(vi)Teaching the topic and asking them to take notes on the salient points of the lesson. The control group was taught the topic using lecture method.

The topic was divided into four weeks of 80 minutes per week. Afterward, PKT and SACPT were administered as posttest. Data obtained were subjected to statistical analysis using mean and ANCOVA (analysis of covariance).

3. Results and Discussion

3.1. Results

Hypothesis 1: There is no significant difference in mean knowledge gain between experimental group and control group students.

Table 1 shows that the calculated F-value, $F_{1,145} = 56.603$ at $p < .05$. This indicates that there is a significant difference, and thus the rejection of Ho1.

In addition, data in Table 2 showed that the significant difference is in favour of the experimental group exposed to brainstorming strategy since the mean in chemistry knowledge test of students in the experimental group increased from a pre knowledge test (PreKT) mean of 57.8219 to a post knowledge test (PostKT) mean of 65.2740 indicating an increase of 7.4521 as mean gain ($\square_{gain}$) in knowledge .

While that of the students in the control group that has been taught through the lecture method increased from a PreKT mean of 55.5467 to a PostkT mean of 57.3067 giving a mean gain ($\square_{gain}$) in knowledge of 1.76 .

Meaning that, brainstorming taps and activates the students' prior knowledge as well as enhances retention of knowledge more than the lecture method.

Table 1: ANCOVA of mean Post Knowledge Test classified by instructional strategies (Groups)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2410.502[a]	2	1205.251	31.855	.000
Intercept	5519.598	1	5519.598	145.882	.000
Pre Knowledge	62.246	1	62.246	1.645	.202
Instructional Groups	2141.633	1	2141.633	56.603	.000
Error	5486.221	145	37.836		
Total	562883.000	148			
Corrected Total	7896.723	147			

a. R Squared = .305 (Adjusted R Squared = .296)

Table 2: Mean Pre-test knowledge, Post-test Knowledge, and Mean knowledge Gained

Instructional Groups	**Experimental Group**			**Control Group**		
	Mean	Std. Deviation	N	Mean	Std. Deviation	N
PreKT	57.8219	6.29449	73	55.5467	6.35502	75
PostKT	65.2740	6.61492	73	57.3067	5.69251	75
Mean Gain	7.4521			1.76		

Hypothesis 2: The mean score in chemistry performance test of students in the experimental group is not significantly different from that of the control group.

Table 3: ANCOVA of mean Posttest scores of students' performance classified by instructional strategies (Groups) and sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4082.599[a]	4	1020.650	17.667	.000
Intercept	2637.390	1	2637.390	45.652	.000
Pretest	1944.569	1	1944.569	33.660	.000
Instructional Groups	1064.040	1	1064.040	18.418	.000
Sex	510.270	1	510.270	8.833	.003
Instructional Groups * Sex	149.227	1	149.227	2.583	.110
Error	8261.320	143	57.771		
Total	473118.000	148			
Corrected Total	12343.919	147			

a. R Squared = .331 (Adjusted R Squared = .312)

A look at table 3 reveals that the F calculated for instructional groups, $F_{1,143}$ =18.418 at p=.000. Since $p_{cal} < .05$, it means that there is a statistically significant difference in the mean performance score of the students in the experimental group and the control group.

Therefore the null hypothesis 2 that predicted no significant difference was rejected. Looking at table 4, it is observed that the experimental group exposed to brainstorming strategy had a higher mean gain in chemistry performance ($\overline{X}_{gain}$ =14.8493) than the control group that has been taught through the lecture method ($\overline{X}_{gain}$ = 11.60), thus the observed significant difference is in favour of the experimental group.

Table 4: Mean Pre-test, Post-test and Mean gain scores in chemistry performance test classified by Instructional strategies (Groups)

Instructional Groups	**Experimental Group**			**Control Group**		
	Mean	Std. Deviation	N	Mean	Std. Deviation	N
Pre-test	44.3562	6.20119	73	41.8800	6.44301	75
Post test	59.2055	9.20290	73	53.4800	7.86089	75
Mean Gain	14.8493			11.6		

Hypothesis 3: There is no significant difference in the mean post test scores between male and female students in the experimental and control groups.

Table 3 also shows that the calculated F value for gender, $F_{1,143} = 8.833$ at p = .003. And since the calculated p< .05, it follows that significant differences exist in the mean post test scores within or between the groups with respect to sex. Thus hypothesis 3 is rejected. A glance at data in Table 5, revealed that the male students had a higher mean gain in chemistry performance ($\overline{X}_{gain}$ =13.6104) than their female cohorts ($\overline{X}_{gain}$ = 9.6197), thus the observed significant difference is in favour of the male students.

Table 5: Mean Pre-test, Post test and Mean gain scores in chemistry performance test classified by Sex

Sex	Male			Female		
	Mean	Std. Deviation	N	Mean	Std. Deviation	N
Post test	57.2727	9.88704	77	54.1972	7.86089	71
Pre-test	43.6623	6.60464	77	44.5775	6.44301	71
Mean Gain	13.6104			9.6197		

To determine the source(s) of the significant difference, a post hoc analysis (multiple comparison) using scheffe (Table 6) showed that within the experimental group, the mean difference ($\overline{X}_{diff}$) in performance between male and female students was 1.4664 at p> .05 indicating no significant difference.

Whereas, within the control group there is a significant difference ($\overline{X}_{diff}$ *= 6.6733 at p<.05*).

Again, between the two instructional groups, significant differences exist between male students in the experimental group and female students in the control group ($\overline{X}_{diff}$ *= 11.0566 at p<.05*) as well as between the experimental and control groups female students ($\overline{X}_{diff}$ *= 9.5902 at p<.05*).

Hypothesis 4: There is no significant interaction effect of instructional strategies and sex on students' academic performance.

Findings from table 3 also showed the F-value for the interaction effect of instructional strategies and sex on students' academic performance, $F_{(1, 133) =}$ 2.583 ast p > 0.05.

Since p> 0.05 it means that the interaction effect was not significant. Hence, HO_4 was retained.

Table 6: Multiple comparison of the mean post test scores between male and female students in the two instructional groups using scheffe

(I) Sex	(J) Sex	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Exp. group Male	Exp.groupFemale	1.4664	1.95782	.905	-4.0719	7.0048
	Ctrl. group Male	4.3833	1.85206	.138	-.8559	9.6225
	Ctrl. groupFemale	11.0566*	2.00442	.000	5.3864	16.7268
Exp. Group Female	Exp. group Male	-1.4664	1.95782	.905	-7.0048	4.0719
	Ctrl. group Male	2.9169	1.88059	.495	-2.4030	8.2368
	Ctrl. groupFemale	9.5902*	2.03081	.000	3.8454	15.3350
Ctrl. group Male	Exp. group Male	-4.3833	1.85206	.138	-9.6225	.8559
	Exp.groupFemale	-2.9169	1.88059	.495	-8.2368	2.4030
	Ctrl. groupFemale	6.6733*	1.92906	.009	1.2163	12.1303
Ctrl. group Female	Exp. group Male	-11.0566*	2.00442	.000	-16.7268	-5.3864
	Exp.groupFemale	-9.5902*	2.03081	.000	-15.3350	-3.8454
	Ctrl. group Male	-6.6733*	1.92906	.009	-12.1303	-1.2163

Based on observed means. The error term is Mean Square (Error) = 68.942.

*The mean difference is significant at the 0.05 level

3.2 Discussion

This study aim at investigating the validity of using brainstorming as an instructional strategy in activating students' prior knowledge as well as promoting academic performance in chemistry. Finding relating to the effect of brainstorming on students' prior knowledge proved brainstorming to be effective in activating students' prior knowledge. This finding lends credence to previous studies [20, 43, 50] that ascertained brainstorming to be effectual in activating prior knowledge, readers schema and promotes learners' reading comprehension. During brainstorming session, pre existing knowledge or schema that may seem dormant or inaccessible is pop up and brought to bear on the current material to be learnt.

On brainstorming and academic performance, the result of this present study is undeviating from that of erstwhile studies [3, 6, 8, 27, 31, 35, 48] that had reported statistically significant difference in mean academic achievement in preference to students who received instructions through brainstorming strategy. Also, pertaining to sex, the result showed that the academic performance of students is statistically significant in favour of male students. This finding is consistent with earlier results [17, 36] that reported gender disparity in male and female students' performance in science and other related fields as they found male students academic performance to be better than that of female. However, Post hoc analysis (see table 6) showed that the significant difference was due to the mean difference in academic performance of male and female students within the control group as well as between the experimental and control groups. While, within the experimental group there was no significant difference. The observed no significant difference in the academic performance between male and female students in the experimental group exposed to brainstorming strategy corroborates the findings of [2, 19, 24, 32, 33, 35, 41] who in their different studies documented no statistically significant difference in the academic achievement of male and female students in the pure sciences. This finding is in disagreement with that of [17, 36]. And thus advance the superiority of brainstorming over lecture method in equal enhancement of both male and female students' academic performance.

The above findings can be credited to the free and conducive learning atmosphere where students are encouraged to generate multiple ideas (both relevant and irrelevant ones) towards solving the task or problem at hand without criticisms but rather evaluated and appropriate ones used while the wrong ones are corrected. Furthermore, the scaffolding nature of brainstorming as an instructional strategy help the students to activate their prior knowledge by engaging them in critical thinking, creative thinking, and enabling them to recognize and correct any misconceived or inappropriate ideas or thoughts. By this, the learner becomes actively involved in learning the academic content, retain knowledge better and achieve academic success.

4. Conclusion, Implications and Recommendations

Results of this study have substantiated that employing brainstorming as a teaching strategy in the teaching of stoichiometric aspect of chemistry to secondary school students was better than using the traditional (lecture) method. Brainstorming promotes meaningful learning as it enables the students to actively engage in learning by encouraging them to generate and share a broad-spectrum of ideas, and correcting the inaccurate ideas, activate their prior knowledge and achieve academic success.

A major implication of this study is that students can effectively learn if they can anchor new knowledge on prior knowledge. And so, in our classrooms, teachers should realize that they can help students to learn school subjects by painstakingly engaging their times to identify and activate students' prior knowledge about the topic they are to be taught, and building the new knowledge upon the pre-existing ones. In addition, the study tacitly suggest that brainstorming can help students to develop academic, cognitive, affective, and social skills that are necessary to function effectively in the society. Following the results of this study, it was recommended that chemistry teachers should employ brainstorming strategy in the teaching of chemistry concepts. Also, science curriculum designers and teachers should respectively design and use appropriate instructional strategies and packages that can evoke students' prior knowledge to promote learning.

References

[1]. Adesoji, F. A. & Ogini, A. M. ''Students' aptitude indices as predictor of learning outcomes in

chemistry''. British Journal of Arts and Social Sciences, 8 (11), 174 – 182, 2012

[2]. Al-blwi, Q. ''The effectiveness of using brainstorming strategy in developing thinking in Islamic education among third secondary students in Tabouk City''. Master Thesis, Mut'a University, Krak, Jordan, 2006.

[3]. Al-harbi, A. ''The effects of brainstorming in developing creative thinking and achievement among first secondary schools students in biology in Arrar City''. Unpublished Master Thesis, Faculty of Education, Mecca, 2002.

[4]. Al-Magharwry, A. ''Effectiveness of using the brainstorming technique to learn some basic skills and collection of knowledge for beginners in volley ball''. World Journal of Sport Sciences, 6(4), 361-366, 2012

[5]. Al-Olimat, A. ''The effects of brainstorming and discovery in teaching science in developing creative thinking''. Al-sharga Humanitarian Sciences Journal, 5(1), 2008

[6]. Alsalamat, M. & Kharabsha. ''Efficiency of using brainstorming strategy in the seventh grade students' achievement and their attitudes toward geography''. Educational Journal, Egypt, 27(3), 357-388, 2010

[7]. Aniodoh, H. C. O. & Eze, G. N. ''Achieving effectiveness in secondary school chemistry classroom using constructivist aapproach. A case study of physical and chemical changes''. Proceedings of the 55th Annual Confernce of STAN, 2014, pp. 247 – 252.

[8]. Ashammari, M. K. ''Effective brainstorming in teaching social studies for elementary schools in Saudi Arabia''. Journal of Education & Social Policy, 2(3), 70 – 75, September, 2015.

[9]. Aurah, C. M. ''The effects of self-efficacy beliefs and metacognition, an academic performance: A mixed method study''. American Journal of Educational Research, 1(8), 334-343, 2013

[10]. Ausubel, D. ''Educational Psychology''. New York: Holt, Rinehart & Winston, 1968

[11]. Bransford, J. D., Brown, A. L. & Cocking, R. R. ''How people learn: Brain, mind, experience and school''. Washington, DC: National Academy Press, 2000

[12]. Bringula, R., Basa, R. S., Cruz, C.D., & Rodrigo, M. M. T. ''Effects of prior knowledge in mathematics on learner – interface interactions in a learning by teaching intelligent tutoring system''. Journal of Educational Computing Reseach, November, 2015. Available: http://www.reseachgate.net/publication/2837, June 2nd, 2016. DOI: 10.1177/ O735633115622213

[13]. Brown, T., LeMay, H., & Bursten, B. ''Chemistry: The central science (12th ed.)''. Upper Saddle River, NJ: Prentice, 2013.

[14]. Coştu, B., Ayas, A. A., Çalick, M., Ünal, S. & Karatas, F. O. ''Using the competence of material science teachers and laboratory determination of solution preparation''. Hacethepe Univ. Fac. Educ. J., 28: 65-72, 2005

[15]. Dochy, F. J. R. C. & Alexander, P. A. ''Mapping prior knowledge. A framework for discussion among researchers''. European Journal of Psychology of Education, 10(3): 225-242, 1995.

[16]. Evans, K. L., Yaron, D., & Leinhardht, G. ''Learning stoichiometry: A comparison of text and multimedia formats''. Chemistry Education Research and Practice,9(3), 208 – 218, 2008.

[17]. Ezeudu, F. O. & Obi, T. N. ''Effects of gender and location on students' achievement in chemistry in secondary schools in Nsukka Local Government Area of Enugu State''. Research on Humanities and Social Sciences, 3(15), 2013. Available: http://pt.slideshare.net/AlexanderDecker, Feb. 25th,2014.

[18]. Fanona, Z. N. ‘‘The effect of using the model of generative learning and brainstorming in the development of concepts and the attitude towards biology for the eleventh grade male students’’. 2012

[19]. Fatokun, K.V.F. & Omenasa, K. A. ‘‘Effect of prior knowledge on students’ achievement in chemistry’’. African Educational Research Journal, 3(3), 184-189, , 2015.

[20]. Feathers, K. M. ‘‘Info Text: Reading and Learning’’. Ontorio: Pippin publishing Corporation, 2004.

[21]. Haider, A., & Al Naqabi, A. ‘‘Emiratti high school students’ understanding of stoichiometry and the influence of metacognition on their understanding. Research in Science Technology Education,26(2), 215 – 237, 2008. Available: http://www.ingentaconnect.com , June 26th, 2016.

[22]. Hand, B., Yang, O., & Brusvoort, C. ‘‘Using writing to learn science strategies to improve year II students’ understanding of stochiometry. International Journal of Science and Mathematics Education, 5(1), 125 – 143, 2007. Doi: 10.1007151763-005-9028-1

[23]. Hashempour, Z., Rostampour, M. & Behjat, F. ‘‘The effect of brainstorming as a pre-writing strategy on EFL advanced learner’s writing ability’’. Journal of Applied Linguistics and Language Research.[On-line] 2(1): 86-99, 2015. Available: www.jallr.ir [May 2nd , 2016]

[24]. Inomiesa, E. A., Achufusi, N. N. & Mgbemena, C. O. ‘‘Effects of self-regulated learning and metacognitive learning cycle on the academic achievement of physics students’’. Open Journal of Advanced Engineering Techniques (OJAET), 1(3), 10-20, 2013.

[25]. Jack, G. U. ‘‘The influence of identified student and school variables on students’ science process skills acquisition’’. Journal of Education and Practice, 4(5), 16-21, 2013

[26]. Jarwan, F. ‘‘Teaching thinking: Definition and applications’’. Amman: Dar Al-fkir. Jordan, 2005.

[27]. Keshwan, B. A. ‘‘To study the effects of brainstorming instructional strategies and simulation games on secondary school students’ achievement in social studies’’. Golden Research Thoughts, 3(11) 1- 5, May, 2014.

[28]. Kihwele, J. E. (2014). ‘‘Students’ perception of science subjects and their attitude in Tanzanian secondary schools’’. World Journal of Educational Research, 1(1), 1 – 8, January, 2014.

[29]. Masoura, E. & Cathercole, S. ‘‘Contrasting contributions of phonological short-term memory and long-term knowledge to vocabulary learning in a foreign language’’. Memory, 13(3 & 4): 422-239, 2005.

[30]. Melaku, M. W., Harrison, A., & Temechegn, E. ‘‘What makes chemistry difficult?’’ AJCE, 4 (1), 31 – 43, 2014[Special issue, part 1]

[31]. Mohammed, K. H. ‘‘Effect of brainstorming on Balga Applied University’s students’ achievement in the course “E 101” and its relation to some variables’’. Journal of Literature, Languages and Linguistics, 20: 81-86, 2016.

[32]. Nbina, J. B. & Obomanu, B. J. ‘‘Assessment of the effects of problem-solving instructional strategies on students’ achievement and retention in chemistry with respect to location in Rivers State’’. World Journal of Education, 11(2), 74-79, 2011.

[33]. Nbina, J. B. ‘‘The effect of instruction in metacognitive self-assessment strategy on chemistry self-efficacy and achievement of senior secondary school students in Rivers State, Nigeria’’. Journal of Research in Education, 3 (2), 83-94, 2012

[34]. Nbina, J. B. (2012a). Analysis of poor performance of senior secondary students in chemistry in Nigeria. African Research Review, An international multidisciplinary Journal, Ethiopia, 6 (4), 324 –

334. [Series No. 27, October, 2012].

[35]. Odoh, C. O. ‘‘Effects of brainstorming on students’ achievements in senior secondary chemistry’’. Journal of Qualitative Education, 9(4): 1-8, May, 2013.

[36]. Ogbuanya, T. C., & Owodunni, A. S. ‘‘Effects of reflective inquiry instructional technique on students’ achievement and interest in radio, television and electronics works in technical colleges’’. IOSR Journal of Engineering (IOSRJEN), 3(11), 01-11, 2013.

[37]. Opara, M. F. ‘‘Application of the learning theories in teaching chemistry: Implication for global competitiveness. International Journal of Scientific and Engineering Research, 4(10), 1224 – 1243, 2013.

[38]. Orji, A. B. C. & Ekpo, G.O. ‘‘Constructivism-based instructional approaches and students’ learning outcomes in environmental education’’. International Journal of Education, Science, Humanities, Mathematics and Environmental Studies (IJESHMES), 5(1&2), 146 – 160, 2013.

[39]. Osborn, A. F.‘‘Applied imagination: Principles and procedures of creative thinking’’. New York: Charles Scribner’s Sons, 1953.

[40]. Osborn, A. F. ‘‘Applied imaginations: Principles and procedures of creative problem solving. (3rd Rev. edition)’’. New York: Charles Scribner’s Sons, 1963.

[41]. Owo, W. J. ‘‘Effects of metacognitive-motivational strategies on the academic achievement of secondary school chemistry students with different psychological profiles in Rivers State’’. An unpublished PhD dissertation, College of Graduate studies, University of Port Harcourt, Nigeria, 2015.

[42]. Piaget, J. ‘‘Piajet’s theory’’, in Handbook of child Psychology, 3rd ed, vol 1. P. Mussen, Ed. New York: Willey,1970, pp 703-732.

[43]. Rashtchi, M. & Beiki, M. ‘‘The effect of teachers’ generated cooperative brainstorming versus learner-generated cooperative brainstorming on activating EFL learners’ background knowledge in essay writing classes’’. Indian Journal of Fundamental and Applied Life Sciences, 5(52): 1218-1227, 2015. Available:www.cibtech.org/sp.ed/jls/2015/02/jls.htm, May 24th , 2016.

[44]. Rizi, C. E., Najafipour, M., Haghani, F. & Dehghan, S. ‘‘The effects of using the brainstorming method on the academic achievement of students in grade five in Tehran elementary schools’’. [2nd World Conference on Educational Technology Researches – WCETR 2012]. Procedia – Social and Behavioural Sciences, 83: 230-233, 2013.

[45]. Robertson, L., Taczak, K. & Yancey, K. B. ‘‘Notes toward a theory of prior knowledge and its role in college composers’ transfer of knowledge and practice’’. Composition Forum 26, 2012. Available: http://composition-forum.com/issue/26/priorknwoeldge-transfer.php, May 20 th , 2016

[46]. Rodrigo, M. M. T., Ong, A., Bringula, R., Basa, R. S., Cruz, C.D., Matsuda, N.‘‘Impact of prior knowledge and teaching strategies on learning by teaching’’. Journal of Educational Computing Reseach, January 2013.Available: http://www.reseachgate.net/publication/2892, June 2nd, 2016.

[47]. Shapiro, A. ‘‘How including prior knowledge as a subject variable may change outcomes of learning research’’. American Educational Research Journal, 41: 159-183, 2004.

[48]. Sodouh, W. ‘‘The effect of using the strategies of brainstorming and computer education in academic achievement and the development of creative thinking skills of sixth grade students in Jordan and their

attitudes towards learning mathematics''. European Scientific Journal, 9(13): 220-238, 2013.

[49]. Udousoro, U. J. ''The effects of gender and mathematics ability on academic performance of students in chemistry''. African Research Review: An international multidisciplinary Journal, Ethiopia,5(4), 201-213, 2011.

[50]. UNC. ''Design and problem solving in technology''. Albany. NY: Delmar, 2014.

[51]. Warsnak, A. D. ''The effects of activating prior knowledge before reading on students with and without learning difficulties''. A thesis submitted to the College of Curriculum and Instruction, and the Faculty of the Graduate School of Wichita State University, 2006.

[52]. Woolfolk, A., Hughes, M. & Walkup, V. Psychology in Education. England, Edinburgh Gate Harlow: Pearson Education Limited, 2008, pp. 38 – 40.