EFFECTS OF EXPLANATIONS AND INTEGRATION OF IDEAS PEDAGOGIES ON SECONDARY SCHOOL CHEMISTRY STUDENTS' ACQUSITION OF BASIC SCIENCE PROCESS SKILLS IN NIGERIA

Dr. Ngozi Okafor

Department of Science and Technology Education

University of Lagos, Nigeria

ngozyokafor@yahoo.com; nokafor@unilag.edu.ng

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Abstract

The thrust of this study was to determine the effects of explanations and integration of ideas on secondary school chemistry students' acquisition of observing and inferring skills in Lagos State of Nigeria. The extent to which gender could influence observing and inferring skills acquisition in chemistry was also ascertained. A null hypothesis was tested. The study adopted a quasi- experimental research design where intact classes were subjected to two treatment groups (explanations and integration of ideas) and a control group (lecture) in a 3x2 factorial matrix. The sample size was 200 participants with the average age of 14 years. Observing Skill Test (OST), Inferring Skill Test (IST) and Guides on Teaching Strategies (GTS) which had three sections were the instruments used in data collection. Data were analyzed using mean, standard deviation and Analysis of Co-variance (ANCOVA). The findings of the study showed significant interaction effects of the teaching methods and gender on chemistry students' acquisition of observing and inferring skills. Integration of Ideas Method (IIM) was most effective, followed by Explanations Method of Teaching (EMT) while Lecture Approach Method (LAM) had the least effect. However, boys out-performed the girls in the observing skill test among all the teaching methods. In addition, boys exposed to IIM out-performed the girls in the inferring skill test but girls taught with EMT and LAM excelled better than boys in the inferring skill test. The pattern of the teaching methods in chemistry students acquisition of observing skill followed this trend: (IIM >EMT > LAM {Boys > Girls}) while the pattern in students acquisition of inferring skill followed this trend: (IIM {Boys > Girls}> EMT > LAM {Boys < Girls}). The study concludes that if learning is to be based on science process skills acquisition, chemistry teachers should plan lessons with effective pedagogies that would provide opportunities for students' to harness basics skills that are required in this present age of science and technology. It recommends that the Nigeria Educational Research and Development Council (NERDC) should ensure that these two pedagogies are included and implemented in the secondary school chemistry curriculum to ensure that no student is left behind in the acquisition of workforce skills in Nigeria.

Keywords: Observing and inferring skills, Basic Science Process Skills, Gender

Introduction

The role of chemistry in the provision of domestic needs, security and social amenities is an indication of its importance to national development. The abstract nature of chemistry concepts attributes to why many students hardly comprehend skills inherent it (Okafor & Olayemi, 2014; Tiberghien, 2000). It is also observed that some students encounter difficulties in acquiring science process skills required for unlocking conceptual abstraction and joblessness. The present economic recession in Nigeria demands that students' acquire one or two basic science process skills that are applicable in the industries and everyday life (Ojo, 2018). This could enhance their competencies in job creation rather than seeking for white collar jobs that are exclusively preserved for the politicians' children or wards. Unfortunately, most drop-out students' without skills embrace kidnapping and stealing as means of livelihood which have tremendous effect to lives and properties of the citizens. Some researchers have identified ill-equipped laboratory, poor classroom management; ineffective teaching pedagogies; gender inequity and negligence on prior knowledge to have significant effects on science process skills acquisition (Adane & Admas, 2011; Chen, Kirkby & Morin, 2006; Okafor, 2014; Okafor, 2013). Science process skills are series of connected actions and experiences that are externally demonstrated by the learners during hands-on activities in the laboratory (Adane & Admas, 2011, Ojo, 2018). They enable students' reason critically as independent thinkers when acquired and applied (Ojo, 2018 & Science-A-Process Approach (SAPA), 2018). Science process skills are grouped into two: basic and integrated science process skills respectively (Ojo, 2018). The basic science process skills are observing, inferring, measuring, communicating, classifying and predicting while integrated science process skills include; controlling variables, defining operationalizing, formulating hypotheses, interpreting data, experimenting and formulating models. This paper therefore considered only observing and inferring basic science process skills as appropriate skills for workplace that are highly demanded in this fourth industrial revolution that harnesses skills acquired without university or college certificates.

Science Process Skills

According to the World Economic Forum, 65% of people today without adequate skills will be losing their jobs. As the fourth industrial revolution ushers in the knowledge economy, the workplace skills are highly demanded. One major way Nigeria could catch up with the fourth industrial revolution is through harnessing observing and inferring skills at the primary and secondary school education to catch them young on the global demands. What sort of reforms and mind-shift will be required in the Nigerian public and private secondary schools for chemistry students to take advantage of this technology revolution era in skills acquisition? Tiberghien (2000); Brooks (2011); Kanari & Millar (2004); Drivers,(2000) posited that appropriate teaching pedagogies, learners friendly classroom and constructivists approaches could help students excel in that direction. Adane & Admas (2011); Okeke, 2001 and Kanari & Millar (2004) stated that hands-on-activities have developed student science process skills acquisition and positive attitude towards science. They further explained that laboratory activities concretize chemistry conceptual knowledge, science process skills acquisition and attitude towards science than the traditional method of teaching. Okafor & Uzoechi (2012) study on utilization of laboratory resources to chemistry instruction indicated that students exposed to hands-on activities had better understanding of science process skills and positive attitude towards chemistry. Ojo

(2018) and Brooks (2011) concluded that science process skills should be taught separately with effective pedagogies that promote 21st century skills and conceptual understanding. This paper therefore determined the extent to which explanations and integration of ideas pedagogies could enhance secondary school chemistry students' acquisition of the two basic science process skills (observing and inferring) in Lagos State of Nigeria.

Explanations Approach

In the past, the teacher was the only source that communicated knowledge, information and ideas across the students without detailed explanations unlike today where technology has made the world a global village. Explanations have helped in solving several teaching-learning problems by engaging learners actively in communication through questions and answers than being passive (Sandoval & Reiser, 2004; Valanides, 2013). In explanations, the teacher breaks the lesson's topic into teachable sub-topics that are within the students' level of understanding. Explanations are rarely used in the classroom resulting to students' difficulties in noting teacher's lesson (Driver, 2000; Sandoval & Reiser, 2004). Constructivist learning theory explains that students' construct personal understanding based on their prior knowledge which the teacher needs to modify through explanations with adequate illustrations (Ausubel, 1968; Driver, 2000; Sandoval & Reiser, 2004). If teachers are to embrace the constructivist learning approach for science process skills acquisition, they need to provide learning experiences that would align with students' conceptions through explanations (Kanari & Millar (2004); Sandoval & Reiser, 2004).

Integration of ideas Pedagogy and Gender Equity

Integration of ideas involves the combination of two or more ideas, opinions, thoughts, impressions or feelings together. In educational setting, integration of ideas connotes restructuring and enhancing students' prior ideas on a given concept before communicating new ideas. These ideas may be formal or informal which are tightly held by the students' (Ausubel, 1968). It is important that the teacher carefully gives adequate explanations with illustrations on the students' initial ideas as well as the new classroom ideas for effective and efficient integration of both ideas. Constructivists in science education shared their views on teaching and learning; '*...knowledge is not transmitted directly from one knower to another, but actively built up by the learner* (Ausubel, 1968; Brooks, 2011; Driver, 2000). The central idea is that learning is constructed by building new knowledge on the foundation of previous learning, but if the previous conceptions are incorrect, meaningful learning and skills acquisitions will be jeopardized (Chen, Kirkby & Morin, 2006; Driver, 2000). Making observations, inferences or predictions and gathering evidences during hands-on activities based on students own interpretations could link their prior knowledge to basic science process skills acquisition which is connected to their everyday life (Ojo, 2018; Tiberghien, 2000; Valanides, 2000). Therefore, if learning is to be based on students' prior knowledge, chemistry teachers can plan lessons that provide opportunities for students' to experience phenomena which run counter to their conceptions for skills acquisition (Okafor & Olayemi, 2014; Valanides, 2000).

Aniche, (2000) carried out a study on statistics of admission patterns in Nigerian university faculties' which revealed that girls had low access to sciences than boys due to role perception, socialization pattern and intellectual inferiority in learning science. She further buttressed that access to meaningful learning of science is possible if girls' are given ample

opportunities to operate scientific equipments and materials from the primary school level. Okafor, (2013) worked on influence of gender on students' attitude in accessing chemistry concepts and found that boys prefer abstract concepts with positive attitude than girls towards chemistry. Nsofor (2001) conducted a survey on cultural impediments of women in science. The results revealed that boys and girls equitably pursued careers in science with improved achievement. Okeke (2001) conducted a study on women in science, technology and mathematics education and found that girls did better than boys in science process skills acquisition and use of scientific language. This paper therefore proposed the need for gender equity in the acquisition of observing and inferring skills to ensure that Nigerian secondary school students are not left behind in this fourth industrial revolution of knowledge economy that harnesses basic skills devoid of university certificates.

Theoretical framework

The Rostock (2004) Model is an international cooperation model that demands the application and understanding of scientific concepts, problem solving, meta-cognitive skill and environmental awareness during group or individual learning. The following procedures are Rostock model of learning: (1) Discussing phenomena; (2) Introducing words and ideas students' enjoy; (3) Dealing with interdisciplinary topics; (4) Putting emphasis on the goals of learning; (5) Awareness of students' on what they know;(6) Explaining natural and environmental phenomena (7) Independent learning by following instructions; (8)Improving communicative skills; (9)Importance of feedback and self-evaluation and (10) Effects of curricula and culture on environmental awareness.

Among the procedures, one and two were applied to the explanations and integration of ideas pedagogies on students' acquisition of observing and inferring skills in chemistry as stated below.

(1)Discussing phenomena: This involves breaking down and giving clarifications on phenomena or concepts envisaged being abstract. This was applied to explanations method of teaching to investigate the interactive learning involved in the acquisition of observing and inferring skills.

(2)Introducing words and ideas students' enjoy: This states that the teaching procedures must introduce words and ideas students enjoy or familiar with. This was applied in the integration of ideas method of teaching by linking students' prior knowledge with the classroom ideas to bring about effective acquisition of observing and inferring skills in chemistry.

Problem

The importance of chemistry to national development has been widely reported (Okafor, 2014; Valanides, 2000). Despite its prime position in Nigerian educational system as a core science subject, several studies showed students' inadequate acquisition of basic science process skills arising from poor teaching pedagogies, gender inequity, inadequate human and laboratory resources among others (Adane & Admas 2011; Okafor & Uzoechi, 2012; Okafor, 2014). Chen, Kirkby & Morin (2006) supported the application of integration of ideas in promoting the role of prior knowledge in process skills acquisition. The reports of Chief Examiners in the past National Examinations Council (NECO) on students poor performance during practical examination in chemistry were based on students' ignorance to: follow practical instructions, carry out experiments, make inference and record

observations accurately. It is also observed that chemistry students participate in hands-on activities without receiving adequate explanations on the theories and principles underlying the concepts. These are strong indications of students' poor acquisition of basic science process skills needed in the workplace and everyday life (Ojo, 2018). In addition, chemistry teachers hardly use hand-on activities that could foster science process skills acquisition required in the industries (Okafor, 2014). Though guided discovery approach was recommended but 'chalk talk' and demonstration methods still dominate. How could explanations and integration of ideas enhance secondary school chemistry students' acquisition of observing and inferring skills required in the fourth industrial revolution that is knowledge driven? Would there be gender equity between girls and boys in the acquisition of these skills when exposed to treatments and control conditions? It is against this backdrop that the thrust of this study is determined. A null hypothesis that guided the study was; H_{O1}:There is no significant interaction effect of explanations, integration of ideas and gender (boys and girls) on secondary school chemistry students acquisition of observing and inferring skills in Lagos State of Nigeria.

Methods

The study adopted a quasi- experimental research design where intact classes were subjected to two treatment groups (explanations and integration of ideas) and a control group (lecture) in a 3x2 factorial matrix. The population consisted of all the Senior Secondary School 2 (SSS 2) chemistry students' in Lagos State. SSS 2 chemistry students were considered appropriate because they were not preparing for any external examinations and had been exposed to some basic concepts in chemistry when they were in SSS 1 such as mole, rusting, acid, base and salt. Items were drawn from rates of reaction claimed to be difficult by SSS 2 students. Two Hundred senior secondary school 2 chemistry students of coeducational public schools from two education districts in Lagos State out of six participated in the study. The schools were selected from each of the districts based on the following criteria:

(i) Well-equipped chemistry laboratory;
(ii) Adequate consumables;
(iii) Teachers with masters degree in education chemistry;
(iv)Co-educational public schools;
(v) Willingness of teachers to participate in the treatments and control procedures.

The selection allowed for equal representation of the schools. Only six schools met the above criteria among all the schools in each of the two sampled education districts. Students in all the chemistry arms of the schools that met the criteria were subjected to each of the teaching strategies (see appendix 1). Respondents that did pre- and post-tests were 200 with the average age of 14 years. Three research instruments used for the study include: (1) Observing Skill Test (OST), (2) Inferring Skill Test (IST) and (3) Guides on Teaching Strategies (GTS) which had three sections {Explanations Teaching Method (ETM); Integration of Ideas Method (IIM) and Lecture Approach Method (LAM)}

Observing Skill Test (OST) and Inferring Skill Test (IST) were adopted with modifications from Science Process Skills Test (SPST) (Ojo (2018). Each had Sections A and B. Section A had two items while Section B had four items respectively (see appendices 2 &3). Each item with correct answer earns five marks and wrong answer zero mark. The total score for

correct answers on each test was 20 marks which depicted acquired skills. Each of the tests duration was 12 minutes as shown below.

Observing Skill Test (OST)
Instruction: Please tick X in the box where appropriate ( ) in **Section A** below
i. Gender: ( ) Girl ( ) Boy
ii. Age: ( ) Below 14 years ( ) Above 14 years

Section B:
Instruction: Please respond to the four items in this section. Your responses would be treated confidentially.
You are given 2 Beakers ($100cm^3$); 2M HCL (in each beaker); 10g of Sample A (Marble chips) and 10g of Sample B (powdered marble)
(1) Record your observations of Samples A and B.

Pour $100cm^3$ of 2M HCL in each of the 2 beakers. At the same time add Sample A into one of the Beakers and Sample B into the other.
(2) Observe and record the rates and duration of effervescence of the 2 Beaker.
(3) Based on your observation, state your inference.
(4) Predict what happens if cubes of sugar and powdered sugar were used in place of samples A and B

Inferring Skill Test (IST)
Instruction: Please tick X in the box where appropriate ( ) in **Section A** below
i. Gender: ( ) Girl ( ) Boy
ii. Age: ( ) Below 14 years ( ) Above 14 years

Section B:
Instruction: Please choose the correct answers from the four options provided. Your responses would be treated confidentially.
(1) A solution of ash turns a certain coloured paper into blue. What can you say about the ash solution? (a) acidic (b) neutral (c) basic.
(2) Austin tried to see what was inside the room through the louver but could not. Perhaps, the louver was (a) tinted (b) ordinary (c) white.
(3) When iodine solution is added to a boiled yam, the yam changes to blue-black. This means that (a) starch is present (b) protein is present (c) fat and oil are present.
(4) When vegetable oil is poured on a white paper, the paper becomes translucent, which means (a) carbohydrate is present (b) protein is present (c) fat and oil are present.

The content and face validity of OST and IST were determined by two science education evaluators. The instruments were modified based on their comments. These were administered to 20 chemistry students of public coeducational schools that did not form part of the study. The items discriminating indices and difficulty levels were computed. Items with moderate difficult levels of 0.4 to 0.6 were retained to ensure positive correlation of items in the entire tests. Students responses were used to determine the

reliability indices using Kuder-Richardson formula 20 (KR-20) with reliability indices of 0.79 and 0.82 respectively for internal consistency.

Guides on Teaching Strategies (GTS) were in three sections; (A) Explanations Method of Teaching (EMT); (B) Integration of Ideas Method (IIM) and (C) Lecture Approach Method (LAM) (see appendix (1). Duration for each of the methods was 40 minutes of one period weekly. This lasted for three weeks with the assistance of the chemistry teachers that received orientation on how to apply the methods. Examples of the procedures are shown below.

Explanations Teaching Method (ETM)
ETM is teacher-student-centred involving discussions and explanations in the treatment group 1. The teacher's role is to lead the students through the topic by breaking it down into simpler sub-topics, giving more clarifications on the concept with questions, activities and examples. The steps to be followed are:

Step1: The teacher introduces the lesson's topic, breaks it down into teachable sub-topics that are within the level of the students, provides illustrative materials and actively engaged students in communication.

Step 2: The teacher asks leading questions with activities, provides answers with explanations by exploring relationships between students' questions and ideas.

Step 3: The teacher guides the students through the activities with explanations, questions and illustrations.

Step 4: Students' ask questions they find difficult in comprehending. The teacher further gives appropriate explanations and students' record answers in their notebooks .

Integration of Ideas Method (IIM)
IIM is also teacher-student-centred in which prior ideas of the students' are linked with the classroom ideas to bring about meaningful learning on the topic in the treatment group 2. The steps below are followed:

Step 1: The teacher provides information on the topic, allowing students to give iinterpretation of their knowledge on the topic.

Step 2: Students' interpret their ideas on the topic that is connected to their everyday lives which are strongly held by them.

Step 3: The teacher restructures students' conceptual knowledge with scientific proof before communicating the new concept. This brings about integration of both their initial ideas and the classroom ideas.

Step 4: Students draw out the conclusion from the classroom activities on how to build new

knowledge from the previous knowledge which may not be absolutely correct.

Step 5: Teacher provides facts, figures, illustrations and questions on the concept that relate to students' experiences and thinking. They are allowed 15 minutes to record their answers in their note books.

Lecture Approach Method (LAM)

The main feature of LAM is teacher-centred which lacks detailed explanations, demonstration, and building of students prior ideas in the classroom setting and this serves as the control group. The procedural steps include:

Step 1: Teacher introduces the topic and asks the students to pay attention without distractions.

Step 2: Teacher talks on the relevance of the topic in students' everyday activities which must not be forgotten.

Step 3: Students listen and watch the procedures involved in the topic.

Step 4: Teacher dictates the note and students copy in their notebook.

Validity and reliability of Guides on Teaching Strategies (GTS) treatment package was done using subject content validation questionnaire administered to three chemistry teachers from three secondary schools that did not partake in the study. The outcomes indicated that teachers strongly agreed with the questionnaire in terms of adequate content coverage as contained in the chemistry curriculum. Pilot study was further done in another two coeducational public schools that did not participate in the study. The feedback from the pilot study was used for improvement on the main study. Students in intact classes were taught with the three teaching methods.

The sample for the study in their intact classes was pre-tested using the three instruments to ascertain the initial differences between groups before the treatment.

Three weeks after the implementation strategies, the sample was post-tested using the same instruments.

Data was analyzed using mean, standard deviation and Analysis of Co-variance (ANCOVA) where pre-test scores served as covariate to take care of the initial differences among the groups. Where significant difference was observed, Bonferoni Post-Hoc test was further used to determine the direction of significant differences.

Results and Discussions

The results of the study are discussed based on the null hypothesis tested.

H_{O1}: There is no significant interaction effect of explanations, integration of ideas and gender on secondary school chemistry students acquisition of observing and inferring skills.

Table 1: Descriptive Statistics of Pre and Post- Treatments (Explanations Method of Teaching (EMT); Integration of Ideas Method (IIM) , (C) Lecture Approach Method (LAM) and Gender) on acquisition of observing and inferring skills.

Treatment	Science Process Skills	Gender	Mean (Pre-test)	Std. Dev.	Mean (Post-test)	Std. Dev.	Mean Difference
EMT	Observing	Boys	2.33	1.50	5.25	0.87	2.92
		Girls	2.48	1.52	4.74	1.59	2.26
	Inferring	Boys	4.44	2.37	11.00	3.41	6.56
		Girls	3.58	1.64	11.54	3.48	7.35
IIM	Observing	Boys	1.87	0.72	5.63	1.03	3.76
		Girls	1.98	1.07	5.41	1.11	3.43
	Inferring	Boys	3.56	1.41	11.13	3.86	7.57
		Girls	4.05	1.67	11.50	3.97	7.45
LAM	Observing	Boys	2.25	1.29	2.31	1.49	0.06
		Girls	1.75	1.30	2.11	1.76	0.01
	Inferring	Boys	2.33	1.78	7.25	5.29	4.92
		Girls	4.36	0.09	11.66	3.45	7.30

Table 1 shows the mean, standard deviation and mean difference before and after treatments on students' acquisition of observing and inferring skills. High mean differences determine the effects of the teaching methods. Based on the mean difference as shown in Table 1 on the acquisition of observing skill, Integration of Ideas Method (IIM) had the highest effect, while boys out-performed the girls in the observing skill test with the mean difference values of 3.76 and 3.43 respectively. This was followed by the Explanations Method of Teaching (EMT) with the mean difference values of 2.92 and 2.26 for boys and girls respectively. The Lecture Approach Method (LAM) had the least effect on the acquisition of observing skill with mean difference values of 0.06 and 0.01 for boys and girls respectively. These entail that boys acquired observing skill better than girls in the three teaching methods.

Table 1 also depicts the mean difference values of boys and girls in acquiring inferring skill when taught with the three different methods. IIM was more effective and boys were better performed than girls with the mean values of 7.57 and 7.45 respectively. This was followed by EMT whereby girls acquired inferring skill better than boys with the mean difference values of 7.35 and 6.56 respectively. LAM was the least effective for inferring skill acquisition whereby girls did better than boys with the mean difference values of 7.30 and 4.92 respectively. These have shown that IIM was more effective than EMT, while LAM was the least in inferring skill acquisition. But, boys acquired better inferring skill than girls when exposed to IIM while girls excelled better than boys in acquisition of inferring skill when exposed to EMT and LAM respectively.

Table 2: Summary of Analysis of Covariance (ANCOVA) of Treatment and Gender on Acquisition of Observing Skill among Chemistry Students.

Sources of Variation	Sum of Squares	Degree of Freedom	Mean of Square	F-ratio	Sig
Main effect	372.822	5	74.564	35.89	.000*
Covariate	2360.426	1	2360.426	1136.12	.000
Treatment	291.271	2	145.636	70.10	.000
Gender	3.047	1	3.047	1.47	.228
Treatment*Gender	0.585	2	0.293	22.14	.869
Within Group	361.506	174	2.078		
Total	3851.000	200			

Table 2 shows that in the treatment condition, the calculated F-value of 35.89 was significant at $p<0.05$ given 2 and 174 degrees of freedom. This means that there is a significant effect of treatment on students' acquisition of observing skill. Also, gender was significant given calculated F-value of 22.14 at $p<0.05$. The .869 accounts for 86% contribution of gender, meaning significant effect of gender. Bonferoni Post Hoc Pairwise comparison analysis was done to confirm the group that differs from others and direction of the difference as shown in Table 4.

Table 3: Summary of Analysis of Covariance (ANCOVA) of Treatment on Acquisition of Inferring Skill among Chemistry Students.

Sources of Variation	Sum of Squares	Degree of Freedom	Mean of Square	F-ratio	Sig
Main effect	206.775	5	41.355	41.355	.015
Covariate	14950.421	1	14950.421	14950.421	.000
Treatment	101.011	2	50.505	50.505	.030*
Gender	103.283	1	103.283	103.283	.008
Treatment*Gender	97.542	2	48.771	48.771	.034
Within Group	2462.803	174	14.154		
Total	25204.000	200			

Table 3 shows a significant effect of the treatment on students acquisition of inferring skill with the calculated F-value of 50.51 at $p<0.05$ given 2 and 174 degrees of freedom. The calculated F-value of 48.77 at $p<0.05$ given 2 and 174 degrees of freedom shows gender influence on students' acquisition of inferring skill. Thus, from Tables 2 and 3, the null hypothesis which states that there is no significant interaction effect of explanations, integration of ideas and gender on secondary school chemistry students' acquisition of observing and inferring skills was rejected while the alternate hypothesis was accepted. Bonferoni Post Hoc Pairwise comparison analysis was done to confirm the group that differs from others and direction of the difference as shown in Table 4.

Table 4:Bonferoni Post Hoc Pairwise Comparison on Treatment and Control Groups

(I) Group	(J) Group	Mean Difference (I-J)	Sig
Integration of Ideas	Lecture Approach	3.260*	0.000
Lecture Approach	Explanations	.920*	0.000
Explanation Method	Lecture Approach	2.340*	0.000

The Post Hoc Pairwise test revealed that chemistry students' exposed to Integration of Ideas Method (IIM) did better than those in Lecture Approach Method (LAM) with (mean difference=3.260; $p=0.000<0.05$). Also students taught with Explanations Method of Teaching (EMT) did better with (mean difference=2.340; $p=0.000<0.05$) while those exposed to Lecture Approach Method (LAM) had the least with (mean difference=.920; $p=0.000<0.05$) in acquiring observing and inferring skills. These imply that IIM was more effective; followed by EMT and LAM (IIM>EMT>LAM) respectively in boosting secondary school chemistry students acquisition of observing and inferring skills in Lagos State of Nigeria.

Discussions

The findings of this study showed significant interaction effects of the teaching methods and gender on chemistry students' acquisition of observing and inferring skills. Integration of Ideas Method (IIM) was most effective, followed by Explanations Method of Teaching (EMT) while Lecture Approach Method (LAM) had the least effect. However, boys out-performed the girls in the observing skill test among the teaching methods. In addition, boys out-performed the girls in the inferring skill test when taught with IIM but girls excelled better than boys in the inferring skill test when taught with EMT and LAM. The pattern of the teaching methods in chemistry students acquisition of observing skill followed this trend: (IIM >EMT > LAM {Boys > Girls}) while the pattern in students acquisition of inferring skill followed this trend: (IIM {Boys > Girls}> EMT > LAM {Boys < Girls}).

The effectiveness of IIM and EMT might be because of the careful application of the procedures that considered the students' prior knowledge with adequate explanations and illustrations during hands-on activities. This corroborates with the assertions of Chen, Kirkby, & Morin,(2006) on the roles of students' prior knowledge in promoting Geo-science education. Rostock (2004) model supports the outcome of the findings that integrated ideas pedagogy can contribute to meaningful understanding of scientific concepts, problem-solving, meta-cognitive skill and environmental awareness during group or individual learning. The results support Ojo (2018) and Brooks (2011) who concluded that science process skills should be taught separately with effective pedagogies that promote skills acquisition and conceptual understanding. More so, the effectiveness of EMT was supported by Sandoval & Reiser (2004) who posited that application of explanations strategy could help students explore relationships between ideas and events in their own learning. The effectiveness of IIM was further buttressed by Ausubel (1968) that students' construct their prior knowledge but teachers could modify it by providing learning experiences that are similar to their ideas. The least effectiveness of LAM corroborates with Okafor (2014) who stated that the passivity of traditional method of teaching would make the learning of chemistry irrelevant and uninteresting. Boys' out-performed the girls in the observing skill test among the teaching methods employed as well as in inferring test when IIM was used. This supports the works of Aniche (2000) and Okafor (2013) which revealed that girls had low access to sciences than boys and boys prefer abstract concepts with positive attitude than girls towards chemistry. The high performance of girls in the inferring skill test when taught with EMT and LAM is in agreement with the findings of Okeke (2001) but contradicts that of Nsofor (2001) that boys and girls perform equitably in science careers. The workforce implication is that boys would be among the trail blazers of

this fourth industrial revolution of knowledge economy that would harness basic skills ahead of the girls.

Conclusion

The present Nigeria educational system responds slowly to the technology and innovations of the fourth industrial revolution knowledge and skills acquisition driven. This trend needs to usher in a paradigm shift on the teaching pedagogies secondary school chemistry teachers employ during classroom instructions. The World Economic Forum, posits that 65% of people today without adequate skills will be losing their jobs to high skilled manpower in this present knowledge economy. One major way Nigeria could catch up with this revolution is through harnessing observing and inferring skills at the primary and secondary school education to catch pupils/students young is this technology era that thirsts for skills acquisition through appropriate implementation of explanations and integration of ideas pedagogies during classroom interactions. These could prepare students that would be higher order thinkers and sustain equitable intellectual superiority of girls and boys for wealth creation and national development. It could be challenging to distinguish the skills acquired by girls and boys separately during hands-on activities noting the overlapping of several related skills and numerous experiences provided during teaching-learning situation. Therefore, if learning is to be based on science process skills acquisition, chemistry teachers should plan lessons with effective pedagogies that would provide opportunities for students' to harness basics skills that are required in this age of science and technology.

Recommendations

Based on the results of the study, the following recommendations are made:

- Principals should create enabling school environment by equipping the laboratories with the desired consumables and non-consumables that will develop learners' interest in hands-on activities for basic science process skills acquisition.
- The pre-service teacher should be adequately prepared on how to apply these two methods to become part of them for professionalization.
- Teacher vacation workshop should be organized annually by the Lagos State ministry of education and made compulsory for all the science teachers to ensure that in-service science teachers benefit from these methods.
- Government should set up implementable monitoring team to ensure that teachers provide students with desirable learning experiences that could lead to acquiring skills. In addition, basic science process skills acquisition centre should be set at a central position by the state government to ensure that the drop-outs are not left behind.
- Motivation and incentives should be given to girls' studying science and chemistry in particular to be able to compete favorably with the boys in any academic exercise.
- The Nigeria Educational Research and Development Council (NERDC) should ensure that these two pedagogies are included and implemented in the secondary school chemistry curriculum to ensure that no student is left behind in the acquisition of workforce skills in Nigeria.

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