
Effect of Science Process Approach on Secondary School Students' Performance and Retention in Practical Chemistry

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Abstract

This study investigated the effect of Science Process Approach on secondary school students' performance and retention in Practical Chemistry in Jalingo Education Zone, Taraba State. A quasi-experimental research design involving pretest and posttest were used for the study. The population comprised all senior secondary school two students of Chemistry; from where a sample of 110 students was drawn. Four research questions and hypotheses guided the study. Two instruments; Science Process Approach Rating Scale (SPARS) and Practical Chemistry Achievement test (PCAT) were used for data collection after been subjected to content and face validation. The reliability of the instrument was established using Cronbach Alpha and a coefficient of 0.84 was obtained. Mean and standard deviation were used to answer the research questions while Analysis of Covariance and t-test were used to test the hypotheses at 0.05 level of significance. The findings revealed that the performance and retention scores of students taught Practical Chemistry using Science Process Approach was higher than those taught using Alternative to Practical Method. But, there was no significant difference in the mean performance and retention scores of both males and females taught with Science process Approach. It is evident from this study that the use of Science Process Approach could enhance students' performance in Practical Chemistry. It is recommended based on the findings that: Chemistry teachers should be encouraged to use Science Process Approach in Practical Chemistry, workshops and seminars should be organized for Chemistry teachers to motivate them adapt new teaching strategies like Science Process Approach that is gender-friendly

Introduction

The knowledge of science has a link with that of technology. Acquisition of scientific and technological knowledge can enhance the development of any nation; this knowledge can be acquired through science education. Science education as opined by Ugwanyi (2015) is the application of principles of education in the development and acquisition of processes/procedures required to help others acquire scientific and technological knowledge for ready application to everyday living. One

of the important science subjects that its knowledge if acquired can be applied in everyday living is Chemistry. Odoh (2016) asserted that Chemistry deals with the composition (what makes up) and the structure of matter. Chemistry at the secondary school level as viewed by Ezeano and Ugwo, (2020), is expected to be taught as a process of inquiry developing in students' cognitive skills, affective skills and psychomotor skills of science. According to Ugwanyi (2015), the cognitive skills are the subject matter of any course in the sciences including its rules, principles, contents, propositions, hypotheses, ideas, theories, concepts and so on. Affective skills include a host of positive or negative constructs, such as attitudes, values, beliefs, opinions and motivation demonstrated towards the study, appreciation and application of Chemistry. This is however very important because the three educational domains are captured in the teaching and learning process which will bring a more balanced outcome to the learner and the society at large as stated in the National Policy on Education.

The New National Policy on Education (FRN, 2013), spells out the requirements for a successful secondary school programme in Chemistry. The objectives of the secondary school Chemistry curriculum as prepared by Comparative Education Study and Adaptation Centre, (CESAC) according to Igwe (2015) are to: i) facilitate a transition in the use of Scientific concepts and techniques acquired in integrated science with Chemistry; ii) provide the students with basic knowledge in chemical concepts and principles through efficient selection of content and sequencing; show Chemistry in its inter-relationship with other subjects; show Chemistry and its link with industry, everyday life, benefits and hazards; and provide a course which is complete for pupils not proceeding to higher education while it is at the same time, a reasonably adequate foundation for a post-secondary Chemistry course. And, an innovation in Chemistry lessons would enable the objectives of the Chemistry curriculum become achievable. There are different methods teachers can use to teach Chemistry one of which is the Science process Approach.

Science process Approach is a teaching strategy that exposes the learners to diverse science process skills. According to Millar (2015), "Process science" (or a "process approach") refers to science courses or programs that emphasize the development of students' "science process skills," that is, their ability to use the "processes of science" in carrying out tasks. These are considered to be the processes which scientists follow when exploring the natural world and developing scientific explanations. There is no complete agreement among science educators on what the specific processes of science are. Most lists of processes however include observing, measuring, classifying, inferring, predicting, hypothesizing, and finding patterns, and some also add: experimenting, planning investigations, controlling variables, communicating, and others. A "process approach" to science contrasts with the more usual "content approach," in which the development of students' practical and inquiry skills is seen as secondary to, or a by-product of the development of their scientific knowledge and understanding of process skills.

Chemistry practical skills are science process skills. They are taught as part and parcel of the chemistry curriculum. Science process skills are cognitive and psycho-motor skills employed in problem solving. Science process skills as opined by Jack (2018) are reasoning abilities which are used by scientists to solve problems, and that the process approach to teaching science is meant to foster inquiry and manipulative skills in students and discourage rote learning. Kamba, Giwa, Libata

and Wakkala (2018) defined science process skills as tools that acquires information about the world and on the other hand is also defined as problem identifier, formulation of the hypothesis about the problem, making valid prediction, identifying and defining of variables, designing and experiment to test the hypothesis. Ozgelen, (2012) viewed science process skills as mental and physical abilities/competencies as well as all the technical “know how” which can be developed in a child and which can be employed in carrying out mental and physical operation in science. The acquisition of science process skills is enhanced by the use of experimental method of teaching which requires learners’ active involvement in lessons.

The shift from the teacher-centred method of teaching science to child-centred activity based method which encourages and develops in the child the spirit of inquiry; an attempt to make students fully aware as well as understand the ways scientists work; and also equipping and preparing students for their possible careers in science and technology led to the development of process skills (Akinbobola & Afolabi, 2012). It is worth noting that for science teaching to be meaningful and relevant, it must adequately reflect the nature of science. That is to say students should be taught what science is and how scientists work. The development of science process skills as opined by Jack (2018) is a very important object of instruction, this is because scientists use them to design and implement procedures for problem solving.

According to Ugwanyi (2015), the American Association for the Advancement of Science (AAAS) classified the science process skills into fifteen. These are observing, measuring, classifying, communicating, predicting, inferring, using number, using space/time relationship, questioning, controlling variables, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. The essence of the Science process approach is to enable the learners acquire science process skills broadly categorized into two viz.: basic and integrated science process skills. Both the basic and integrated science process skills are very important in the teaching and learning of Chemistry. The basic science process skills are observation, classification, and prediction, inferring, communicating and measuring. The basic process skills are foundational tools for construction of new knowledge. The integrated science process skills are controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting and formulating models. This study identified level of acquisition of seven (7) out of the fifteen (15) science process skills. These comprised of five (5) basic science process skills: observation, measuring, recording, communication and inferring skills; and two (2) integrated science process skills: controlling variables and experimenting.

Ajaja (2010) stated that process skills are fundamental to science, which allows everyone to conduct investigation and reach conclusions. Ajaja (2010) also observed that there is a serious educational gap both in bringing these skills into the classroom and in the training of teachers to use them effectively. The skills in chemistry practical activities, both in quantitative and qualitative analysis cannot be completed without creativity. Practical work is not just putting the apparatuses together when seen, but it needs planning, designing a problem, creating new approach and procedure and also putting familiar things together in the new arrangement. This implies that the knowledge of

creativity exhibited by candidates in any practical class helps them to manipulate some practical equipment and enhance their performance in practical Chemistry.

Performance is an important academic factor which is a measurable change in students' behaviour that is influenced by teaching strategies. Muhammed (2020) sees performance as the process of getting something done effectively and successfully using effort and skills aimed at accomplishment of academic goals. According to Narad and Abdullah (2016), academic performance is the knowledge gained which is assessed by marks by a teacher and/or educational goals set by students and teachers to be achieved over a specific period of time. When students perform well in a given task, there is that tendency that the knowledge they have gained is retained in their memories.

The knowledge retention of concepts as opined by Philip (2013) is the ability to remember facts and other information. As further viewed by Philip (2013) concept retention is the ability to remember fundamental concepts rather than "just" facts. Students should not only remember the scales of measurement for example, but should be able to measure objects in real life. Retention is an ability to recall or recognize what has been learned or experienced; or the course of absorbing information and eventually retaining the information overtime, irrespective of ones gender.

Gender issues or differences have been linked with performance of students in academic tasks in several studies but without any definite conclusion. With the world declaration on Education for All (EFA) according to Ezeudu and Obi (2013), it is expected that the learning experience offered to the children in schools should not discriminate against males and females. There is the need to see that both boys and girls are given equal access to education especially in science (chemistry). One of the Sustainable Development Goals (SDGs) is gender equality. As viewed by Ajayi and Ogbeba (2017), studies on gender differences in chemistry performance continue to yield inconsistency results and it has usually been attributed to unequal exposure of males and females to learning instructions; since learners have different characteristics. Suleiman (2011) investigated whether gender difference has any effect on science achievement, and the result from the findings revealed that; males are more interested in studying sciences than females. The report by Adesulu, (2014) also has shown that in Nigeria females' achievement is low as compared to their male counterparts in Basic Sciences, particularly in chemistry. However, some studies (Ajayi & Ogbeba, 2017; Jack, 2013; Jack & Japhet, 2020) show that gender does not affect students' academic achievement when the male and female are taught under the same condition. This shows that the issue of gender in chemistry achievement is not yet been resolved. Hence, the need for further study is required mostly in the present study area (Jalingo, Taraba State) where there still exists research gap. It is believed that the gap between male and female students' academic achievement and performance as applicable in this study, could be filled through the use of appropriate instructional strategies in the teaching of chemistry.

Chemistry has a crucial role in the rapid developments in science and technology. In spite of this, Chemistry is taught in most schools in a very abstract manner without practical experiences. This has resulted to students' low acquisition of science process skills which have become more evident in the mass failure of students in the subject in secondary certificate examinations like National Examination Council (NECO) and West African Examination Council (WAEC). For

example, the West African Examination Council Chief Examiner's report, (2017) revealed the following weakness of candidates in chemistry: lack of knowledge of IUPAC system of naming; poor knowledge of symbols, formulae and equations, inadequate practical exposure which can be as a result of poor acquisition of science process skills, lack of understanding of nuclear chemistry; lack of understanding of basic concepts and principles; Inability to answer questions in electrolysis, lack of understanding of re-dox reactions; and poor knowledge of factors affecting rates of chemical reactions. Also, WAEC Chief Examiners' report (2019) on Chemistry shows that students had the following weaknesses; unable to distinguish between dehydrating agent, Inability to state the correct observation of simple experiments (e.g. precipitates were incorrectly described, and inferences stated did not correspond to observations recorded), inability to outline how recrystallization is carried out in the laboratory. And, all the questions asked to test chemistry students' knowledge in practical skills require that they demonstrate one form of process skill or the other. The inability of students to carry out these activities properly results in low scores in the test of practical knowledge thereby leading to the frequently observed rate of poor performance in chemistry and science as a whole.

More so, based on the literatures reviewed, effects of Science Process Approach on secondary school students performance and retention in terms of gender difference especially among Chemistry students in Taraba State of Nigeria has not been sufficiently investigated; hence a research gap in the study area. The present study intends to cover the following research gaps in the teaching of Chemistry at the Secondary School level which were not covered by the previous studies as indicated as follows: i) teaching Chemistry practical in SSII using the Science Process Approach to ascertain if it will enhance students process skills acquisition; ii) comparing the effect of teaching Chemistry practical in SSII using the Science Process Approach with that of Alternative to practical method of teaching on students' performance and retention of chemistry concepts; and iii) examining gender as a variable in other to ascertain whether Science Process Approach is gender friendly or not.

The purpose of this study therefore is to investigate the effects of science process approach on secondary school students' performance and retention in Practical Chemistry in Jalingo, Taraba State, Nigeria.

The following research questions guided the study:

1. What is the difference in the mean performance scores of students taught practical chemistry using the science process approach compared to their counterparts taught the same concepts of practical chemistry using the alternative to practical method?
2. What is the difference in the mean performance scores of male and female students taught practical chemistry using science process approach compared with students taught using the alternative to practical method?
3. What is the difference in the mean retention scores of students taught practical chemistry using the science process approach compared to their counterparts taught using the alternative to practical method?

4. What is the difference in the mean retention scores of male and female students exposed to science process approach in practical Chemistry compared with their counterparts taught the same concepts of practical Chemistry using the alternative to practical method of teaching?

To also guide the study, the following null hypotheses were tested at 0.05 level of significance:

H₀₁: There is no significant difference in the mean performance scores of students taught Practical chemistry using science process approach and the students taught same concepts using the Alternative to practical method.

H₀₂: There is no significant difference in the mean performance scores of male and female students taught Practical chemistry using science process approach and those taught the same concepts using the Alternative to Practical method of teaching.

H₀₃: There is no significant difference in the mean retention scores of Students taught Practical chemistry using science process approach and the students taught same concepts using the Alternative to Practical method.

H₀₄: There is no significant difference in the mean retention scores of male and female students taught Practical chemistry using science process approach and those taught the same concepts using the Alternative to Practical method.

Methods

The research design that was adopted for this work was the quasi-experimental design. The area of this study is Jalingo Education Zone of Taraba State, Nigeria. The population consisted of all SS2 students of Chemistry in 2020/2021 academic session. The research adopted a multi-stage sampling procedure. The multi-stage sampling procedure consisted of number of distinct stages. In stage one, Jalingo Local Government Area was selected from the three Local Government Areas in the Education Zone through simple random sampling. In stage two, two public Secondary Schools (Government Science Secondary School Jalingo and Government Day Secondary School, Nukkai) from the selected Local government that have a good working standard laboratory with qualified teachers and laboratory assistants which were purposively selected to avoid the influence of students' variable in the study. In stage three- selection of two intact classes (randomly allocated to two groups A and B) using hat and draw technique from the two secondary schools. Also, through hat and draw technique, Groups A and B; were randomly assigned as Experimental group (EG) taught with Science Process Approach (SPA); and control group (CG) taught using Alternative to Practical Method (ALTP) respectively. The sample comprised of 110 students from the two groups (EG=50 & CG=60) made up of 60 males and 50 females.

The instruments used for collection of data for this study were the Science Process Approach Rating Scale (SPARS) adapted from (Ugwu, 2009); and practical Chemistry performance test (PCPT) adopted from WASSCE (2018). The instrument SPARS consists of two sections – section A and B. Section A was concerned with the background information relating to the students such as

name, school and sex. While section B consisted of schedule of practical activities under each science process skill. The five science process skills that the students were assessed on in this study include: observation, measurement, recording, experimenting and inference skills. The 37 items consist of 18 quantitative analysis (QA) items and 19 qualitative analysis (QA) items. The raters/teachers rated the students using scale points of: Very Good (VG) – 4 points, Good (G) - 3 points, Fair (F) - 2 points and Poor (P) - 1 point.

The instruments, SPARS and PCPT were given to three experts for face and content validation in order to establish the validity of the instrument by proper scrutiny for clarity and simplicity of language of the items. Based on the observations of these experts, the items of the instrument were corrected and modified properly before it was pilot tested for reliability.

In order to determine the reliability of the instruments (SPARS) and (PCPT), a pilot test of was done using an equivalent sample intact class of 40 students from a government secondary school in a different education zone in Taraba State. The internal consistency was established with the scores of the students using Statistical Package for Social Sciences (SPSS). Cronbach Alpha was used to establish the reliability index of 0.84 which was considered good and suitable for the study.

The pre-test was administered to the students in the experimental and control groups. This was done a week before the treatment commenced in order to determine the group equivalent. After the pre-test, the students were taught practical chemistry for a period of four weeks (treatment). Two lesson plans were prepared based on quantitative and qualitative analysis, and was used in teaching Chemistry practical for the experimental group taught with Science Process Approach and the control group taught with Alternative to practical method. At the end of the fourth week, the researcher administered the instruments, SPARS and PCPT in order to determine the academic performance of the students in the experimental and control groups. Then, the students had a break of two weeks. Thereafter, the SPARS and PCPT were re-administered after reshuffling the items to the experimental and control group in order to determine the retention level of the students in these two groups

In this study, the data collected was analysed using Mean and standard deviation in order to answer the research questions. A mean score of 25 and above on a skill was considered to be high level of acquisition of the Science process skills while a mean score of below 25 was considered as indicator of low level of acquisition of the skills. This was analysed using Statistical Package for Social Science (SPSS) version 22. Hypotheses 1, 2 and 4, were tested using two-way Analysis of Covariance (ANCOVA) which is appropriate in order to ensure that initial group differences are taken care of statistically; while the independent t test statistics was used to test H_{03} . All the hypotheses were tested at .05 alpha level of significance.

Results

Research Question One

What is the difference in the mean performance scores of students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical Method?

Table 1: Descriptive statistics on mean performance scores of students taught practical Chemistry using Science process Approach and Alternative to practical method.

Group	N	Pre-test		Post-test		Mean Gain
		Mean	Std. Dev	Mean	Std. Dev	
SPA	50	20.18	5.97	42.50	4.57	22.36
ALTP	60	17.08	3.39	29.70	5.08	12.62

Results in Table 1 shows that the post-test performance mean scores of students taught using Science process Approach (SPA) is 42.54 with standard deviation of 4.57, while that of those taught using the Alternative to practical method is 29.70 with standard deviation of 5.08. The difference between the pre-test and post-test performance mean scores of Science process Approach is 22.36 and that of the Alternative to Practical is 12.62. This shows that the post-test mean scores are significantly higher than the pre-test scores for both the two study groups especially among the Science Process Approach. This implies that students taught practical chemistry using the Science Process Approach performed better than their counterparts taught same concepts using the Alternative to Practical method.

Research Question Two

What is the difference in the mean performance scores of male and female students taught practical Chemistry using Science Process Approach compared with the students taught using Alternative to practical method?

Table 2: Descriptive statistics on mean performance scores of male and female students taught Practical Chemistry using Science Process Approach and Alternative to Practical method.

Group	Gender	N	Pretest		Posttest		Mean Gain
			Mean	Std. Dev	Mean	Std. Dev	
SPA	Male	28	28.75	6.94	41.39	4.54	12.64
	Female	22	29.18	6.93	40.23	4.61	11.05
Mean difference			0.43		1.16		1.59
ALTP	Male	32	22.45	5.84	28.84	5.06	6.39
	Female	28	25.75	5.39	27.45	5.41	1.7
Mean difference			3.3		1.39		4.69

From Table 2, it can be seen that the post-test mean performance scores of male students taught practical Chemistry using the Science process Approach is 41.39, while that of the female is 40.23. The difference between the pre-test and post-test mean scores of the male students taught using Science Process Approach is 12.64 and that of the female is 11.05. The difference in the post-test

mean scores of the two sexes is 1.16. The implication is that male students taught practical Chemistry using Science process Approach performed better than their female counterparts.

It can also be seen that the post-test mean performance scores of male students taught using the Alternative to practical method is 28.84, while that of the female students is 27.45. The difference between the pre-test and post-test mean scores of male students taught using the alternative to practical method is 6.39 while that of the female students is 1.7. The difference between the post-test mean scores of the both sexes is 1.39, in favour of the male students. The post-test mean differences show that male students taught practical chemistry using the alternative to practical method performed better than their female counterparts.

Research Question Three

What is the difference in the mean retention scores of students taught practical Chemistry using the Science process Approach and the same concepts using the Alternative to practical method?

Table 3: Descriptive statistics on mean retention scores of students taught practical Chemistry using Science Process Approach and Alternative to practical method.

Variable	Group	N	Mean	Std. Dev.	Mean Diff.
Mean Retention	SPA	50	39.40	4.34	17.31
	ALTP	60	22.08	4.95	

The results of the descriptive mean statistics in Table 3 revealed that huge difference exists in the mean retention scores of students taught Practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method. Their computed Mean retention scores are 39.40 and 22.08 by students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method respectively with a mean retention difference of 17.31 in favour of the students taught practical Chemistry using Science process Approach. This shows that the students taught practical Chemistry using Science Process Approach have higher mean retention than those students taught same concepts using Alternative to Practical method; but was tested to determine if the difference was significant.

Research Question Four

What is the difference in the mean retention scores of male and female students exposed to Science Process Approach in Practical Chemistry compared with their counterparts taught the same concepts of practical Chemistry using the Alternative to practical method of teaching?

Table 4: Descriptive statistics on mean retention scores of male and female students taught practical Chemistry using Science Process Approach and Alternative to Practical method.

Group	Gender	N	P o s t t e s t		P o s t - p o s t t e s t		MeanGain
			Mean	Std. Dev	Mean	Std. Dev	
SPA	Male	28	41.39	4.54	40.57	3.56	0.82
	Female	22	40.23	4.61	39.68	4.09	0.55
Mean difference			1.16		0.89		
ALTP	Male	32	28.84	5.06	26.34	3.97	2.5
	Female	28	27.45	5.41	24.19	4.15	3.26
Mean difference			1.39		2.15		

From Table 4, it can be seen that the post-post-test mean scores of male students taught practical Chemistry using Science process Approach is 40.57, while that of the female students is 39.68. The difference between the post-test and post-post-test mean scores of male students taught using Science process Approach is 0.82 and that of the female students is 0.55. This suggests that the male students taught practical Chemistry using Science process Approach had a higher retentive ability than their female counterparts.

On the other hand, the post-posttest mean scores of male students taught practical Chemistry using the Alternative to Practical method is 26.34, while that of the female students is 22.96. The difference between the posttest and post-posttest mean scores of male students taught using the alternative to practical is 2.5 and that of the female students is 3.26. The difference between the post-posttest mean scores of the two sexes is 2.15 in favour of the male students. The posttest and post-posttest mean differences show that the male students taught practical Chemistry using the alternative to Practical method were able to retain better than their female counterparts.

Hypothesis One

There is no significant difference in the mean performance scores of students taught Practical Chemistry using Science process Approach and the students taught same concepts using the Alternative to Practical method.

Table 5: Analysis of Covariance (ANCOVA) on mean performance scores of students taught practical Chemistry using Science Process Approach and Alternative to practical method.

Source of Variation	Sums of Squares	df	Mean Square	F	Sig.
Corrected Model	19656.895a	3	6552.298	278.944	.000
Intercept	149878.125	1	149878.125	6380.591	.000
Pre-test	5295.005	1	5295.005	651.137	.080
Groups	1185.845	1	1185.845	50.484	.000
Error	4603.980	106	23.490		
Total	174139.000	110			
Corrected Total	24260.875	109			

a. R Squared=.810 (Adjusted R Squared = .807)

The outcome of the Analysis of Covariance (ANCOVA) on Table 5 revealed significant difference exist in the mean performance scores of students taught practical Chemistry using Science process Approach and the students taught the same concepts using the Alternative to practical method. Reason being that the p value of 0.000 in the test versus group is lower than 0.05 alpha level (that is $p < 0.05$, decision= significant) and the computed F value of 50.484 is greater than the 3.000 F critical value. Since $p < 0.05$, and the decision is significant; therefore the null hypothesis which state that there is no significant difference in the mean performance scores of students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method, is hereby rejected.

Hypothesis Two

There is no significant difference in the mean performance scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to practical method.

Table 6: Analysis of Covariance (ANCOVA) on mean performance scores of male and female students taught practical Chemistry using Science Process Approach and Alternative to practical method.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig
Corrected Model	5115.407 ^a	3	1705.136	69.893	.000
Intercept	125253.701	1	125253.701	5134.121	.000
Gender	122.470	1	122.470	5.020	.000
Groups	4930.870	1	4930.870	202.115	.000
Gender * Groups	25.098	1	25.098	1.029	.000
Error	2586.011	106	24.396		
Total	1313350.000	110			
Corrected Total	7701.418	109			

a. R Squared = .664 (Adjusted R Squared = .655)

Results of the ANCOVA statistics on Table 6 showed that there is no significant difference in the mean performance scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to Practical method. Reason being that the p value of 0.313 of the gender versus groups is greater than the 0.05 and the computed F value of 1.029 is lower than the 3.000 F critical value. The descriptive statistics showed that among the students taught Science Process Approach male and female performance scores are 41.39 and 40.23 for male and female respectively on the other hand students taught with Alternative to Practical male and female scores are 28.84 and 25.75 respectively. This shows that among each of the study groups the male and female scores are the same in terms of their mean performance.

Therefore the null hypothesis which state that there is no significant difference in the mean performance scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to Practical method, is hereby accepted and retained.

Hypothesis Three: There is no significant difference in the mean retention scores of students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method.

Table 7: Independent t test statistics on mean retention scores of students taught practical Chemistry using Science Process Approach and Alternative to Practical method.

Variable	Group	N	Mean	Std. Dev.	Mean Diff.	Df	t-computed	t-critical	p-value
Mean Retention	SPA	50	39.40	4.34	17.31	108	19.31	1.96	0.00
	ALTP	60	22.08	4.95					

P value < 0.05, t computed > 1.96 at df 108

Outcome of the Independent t-test statistics revealed that significant difference exists in the mean retention scores of students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method. This is because the calculated p value of 0.000 is lower than the 0.05 alpha level of significance and the computed t value of 19.311 is greater than the 0.05 alpha level of significance. Their computed Mean retention are 39.400 and 22.083 by students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method respectively with a mean retention difference of 17.31 in favour of the students taught practical Chemistry using Science Process Approach. This shows that the students taught practical Chemistry using Science Process Approach had significantly higher mean retention than those students taught same concepts using the Alternative to Practical method. Therefore the null hypothesis which states that there is no significant difference in the mean retention scores of students taught practical Chemistry using Science Process Approach and the students taught same concepts using the Alternative to Practical method, is hereby rejected.

Hypothesis Four:

There is no significant difference in the mean retention scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to Practical method.

Table 8: Analysis of Covariance (ANCOVA) on mean retention scores of male and female students taught practical Chemistry using Science Process Approach and Alternative to practical method.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig
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Corrected Model	8391.194 ^a	3	2797.065	191.347	.000
Intercept	128850.512	1	128850.512	8814.667	.000
Gender	139.895	1	139.895	9.570	.002
Groups	7350.596	1	7350.596	502.854	.000
Gender * Groups	47.586	1	47.586	1.255	.073
Error	1958.777	106	14.618		
Total	134430.000	110			
Corrected Total	10349.971	109			

R Squared = .811 (Adjusted R Squared =.807)

Results of the ANCOVA statistics on Table 8 showed that there is no significant difference in the mean retention scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to Practical method. Reason being that the p value of 0.073 of the gender versus groups is greater than the 0.05 and the computed F value of 1.255 is lower than the 3.000 F critical value. The descriptive statistics showed that among the students taught using Science Process Approach male and female scores are 40.57 and 39.68 for male and female respectively on the other hand students taught practical Chemistry with Alternative to Practical method male and female scores are 26.34 and 22.96 respectively. This shows that among each of the two study groups the male and female scores are the same. Therefore the null hypothesis which states that there is no significant difference in the mean retention scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to practical method, is hereby retained.

Discussion of Findings

The findings of this study are discussed under three major areas: effect of treatment on students' performance, effect of treatment on students' retention and effect of treatment on gender.

On the effect of treatment on students' performance in Practical Chemistry, the findings has shown that students taught practical Chemistry using Science Process Approach (SPA) performed better than their counterparts taught same concepts using the Alternative to Practical method (ALTP). The post-test and post-posttest mean scores of the students taught practical Chemistry using Science Process Approach were found to be significantly different from those of their counterparts taught same concepts using the Alternative to practical method. This therefore implies that there is a significant different between the experimental and control group; in favour of the experimental group that was taught chemistry using Science Process Approach. The finding has revealed that the use of Science Process Approach in the teaching of Practical Chemistry has proven to be more effective in enhancing students' performance in practical Chemistry. The findings of this study agrees with that of Chebii, Wachanga and Kiboss (2013) in Kenya who investigated the effectiveness of Science process skill mastery learning approach on students' acquisition of practical skills and found out that

students taught practical Chemistry using the Science Process Approach performed better than their counterparts in the control group. The findings is also in line with Babafemi, (2014) who opined that students taught using experimental method perform better academically, acquire more science process skills and retain better the concepts learnt than those taught using lecture method. The research result is also consistent with that of Afif and Majdi (2015) who conducted a research on Palestinian secondary school students and observed that the traditional methods of teaching cannot develop the integrated science process skills needed to bring about an all-round improvement in the teaching and learning of science. The finding also supports that of Obochi and Samuel (2018) who revealed that there was a significant difference between the acquisition of science process-skill of students that have prior exposure to laboratory apparatus and those taught using lecture methods in Zaria, Kaduna State. The finding also supports Muhammad and Yusuf (2020) whose results revealed that the subjects exposed to science process skills approach, achieved significantly better than their counterparts exposed to lecture method of instruction in Kaduna State, Nigeria.

On the effect of treatment on students' retention, the results show that the post-posttest mean retention scores of students taught practical Chemistry with Science process Approach was significantly higher than those of the students taught same concepts using the Alternative to practical method of teaching. This implies that students taught Practical Chemistry using Science Process Approach were able to retain learned concepts better than those students taught same concepts using the alternative to Practical method. This finding is in line with Ranpura (2013) who pointed out that memories can be reinforced independently of context by paying careful attention and by consciously attempting to remember. This may imply that memories or retention of concepts and science process skills acquisition start with what students observe through personal experiences in learning environment as clearly and meaningfully as possible.

On the effect of treatment on gender, results of the ANCOVA statistics on Table 6 showed that there is no significant difference in the mean performance scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to Practical method. Also results on Table 8 showed that there is no significant difference in the mean retention scores of male and female students taught practical Chemistry using Science Process Approach and those taught the same concepts using the Alternative to Practical method. The implication is that male students taught practical Chemistry using Science Process Approach had almost the same mean performance and retention scores with their female counterparts. The findings of this study also agrees with that of Jack (2013) who reported that gender does not influence acquisition of Science process skills. The finding also supports previous results by Ajayi and Ogbeba, (2017) in Benue State and, Jack and Japhet, (2020) in Taraba State; who revealed that gender does not affect students' academic achievement when the male and female are taught under the same condition. This implies that the teaching method is gender friendly as both male and female participants benefited from it; since their academic performances were not significantly different on the basis of their sex status. The findings of the present study contradict the works of Sylvanus and Eke (2017) in Rivers State who asserted that gender has significant effect on students' academic achievement in chemistry and showed that male students achieved higher than their female counterparts; and Ezeodu and Obi (2013) in Enugu State who revealed that male students achieved significantly better than female students. These contrary results may have been due to students

differences not fully considered to yield maximum learning outcomes in a gender-friendly chemistry class.

Conclusion

On the basis of the outcome of the study, it can be significantly concluded that the use of Science Process Approach is very effective for the teaching of practical chemistry in secondary schools and it is very gender friendly especially when this method is compared with the alternative to the practical method. Hence, the study helped students to have a first-hand knowledge on science process skills such as observing, measuring, recording, experimenting and inferring.

Recommendations

On the basis of this study, the researcher put forward the following recommendations:

- i. School supervisors and Heads of schools should ensure that the use of Science Process Approach is encouraged and recommended in all schools for the effective implementation of the practical chemistry curriculum by regular supervision and monitoring.
- ii. Ministry of Education and school proprietors should ensure that Chemistry teachers' are trained to use modern effective teaching methods especially Science Process Approach through sponsorship to workshops, seminars and even further trainings.
- iii. Since science process approach have been proven to enhance students' performance in practical chemistry, hence teachers of Chemistry should give students enough opportunity to explore divers practical activities in the laboratories as this will enable them develop science process skills.

References

- Adesulu, D. (2014). *Mass failure as WAEC releases May/June exams result*. (2-6). Available <http://vangurdngr.com> 4th August, 2014.
- Afif, H. Z. & Majdi, R. J., (2015). Science process skills and attitudes toward science among secondary school students. *World Journal of Education*, 5(1), 13-24.
- Ajaja, O. P. (2010). Processes of science skills acquisition: competencies required of teachers for imparting them. *Journal of quality education*, 6 (4), 6-12.
- Ajayi, V. O. & Ogbeba J. (2017). Effect of gender on senior secondary chemistry students' achievement in stoichiometry using hands-on activities. *American Journal of educational research*, 5(8), 839-842. DOI: 10.12691/education-5-8-1.
- Akinbobola, A. O. & Afolabi, F. O. (2012). Analysis of science process skills in West African senior secondary school certificate physics practical examinations in Nigeria. *American-European Journal of science research*, 5(4), 234-240.
- Babafemi, A. J. (2014). Impact of prior exposure to laboratory apparatus on acquisition of process skills and academic performance in Chemistry at Secondary Schools in GIWA Zone, Nigeria. *American Journal of Educational Research*, 4 (12), 903-906.

- Chebii, R., Wachanga, S., & Kiboss, K. (2012). Effects of Science Process Skills Mastery Learning Approach on Students' Acquisition of Selected Chemistry Practical Skills in School. *Creative Education*, 3, 1291-1296. <https://doi.org/10.4236/ce.2012.38188>.
- Ezeudu, F. O. & Obi, T.N. (2013). Effect of Gender and Location on Students' Achievement in Chemistry in Secondary Schools in Nsukka Local Government Area of Enugu State, Nigeria. *Research on Humanities and Social Sciences*. 3 (15): 50-55.
- Ezeano, C. A. & Ugwo, M. I. (2020). Effects of laboratory teaching method on senior secondary school students' academic achievement in inorganic chemistry. *International journal of arts and sciences (IJOTAS)*, 3(5), 2020.
- Federal Ministry of Education (2013). *National Policy on Education* (4th edition). Abuja, NERDC Press.
- Igwe, I. O. (2015). Secondary Education Chemistry Curriculum Implementation in Nigeria: Contending Issues and Innovative Approaches for the Future. *IJSAR Journal of Life and Applied Sciences (IJSAR-JLAS)*, 3 (1), 24-33.
- Jack, G. U. (2013). The influence of identified student and school variables on students' science process skills acquisition. *Journal of education practice*, 4(5) 16-22.
- Jack, G. U. & Japhet, J. (2020). Effects of Multiple Intelligence Teaching Strategy on Students' academic achievement and attitudes towards Chemistry in Jalingo Education Zone of Taraba State, Nigeria. *Ilorin Journal of Education*, 40, 2020, 1-15.
- Jack, G. U. (2018). Chemistry Students' Science Process Skills Acquisition: Influence of Gender and Class size. *Global Research in Higher Education*, 1(1), 80-97.
- Kamba, A. H.; Giwa, A. A.; Libata, I. A. & Wakkala, G. T. (2018). The relationship between science process skills and student attitude toward physics in senior secondary school in Aliero metropolis. *African Educational Research Journal*, 6(3): 107-113.
- Millar, R. (2015). Process science. In R. Gunstone (Ed.), *Encyclopedia of science Education* (pp.796-7). Dordrecht: Springer.
- Muhammad, B. A. & Yusuf, S. D. (2020). Effects of science process approach and lecture method on academic achievement of pre-service chemistry teachers in Kaduna state, Nigeria. *ATBU journal of science, technology and education*, 4(2), 115- 119.
- Obochi, M. U. & Samuel, E. (2018). Impact of Laboratory activities and acquisition of process skills on attitude and academic performance in science among Senior Secondary School Students in Zaria, Kaduna State. *ATBU, Journal of Science, Technology & Education (JOSTE)*, 6(4), 20-17.
- Odoh, C. (2016). Effects of hands-on activities on psychomotor skills acquisition of senior secondary two chemistry students. *Journal of science, technology, mathematics and entrepreneurial education (JSTMEE)*, 1(1) 73-89.

- Oloyede, O. I. (2012). The Relationship between Acquisition of Science Process Skills, Formal Reasoning and ability. *International Journals of IJAAS*, 8(1), 1 – 4.
- Ozgelen, S. (2012). Students' science process skills within a cognitive domain framework. *Eurasia Journal of mathematics, science & technology education*, 8(4) 283-292.
- Philip, P. (2013). *Factors Affecting Concept Retention*. American society for engineering Education.
- Ranpura, A. (2013). *Learning and memory: How we remember and how we forget*. Yale University. Retrieved from brainconnection.brainhq.com/2013.
- Suleiman, A .M. (2011). *Effect of inquiry method on Academic Achievement, Retention & Attitude towards Chemistry among Diploma in Kano State Polytechnic*. Unpublished Masters Dissertation.
- Sylvanus, T. & Eke, S. (2017). Effect of inquiry teaching strategy on academic achievement of senior secondary school chemistry students in Okrika Local Government Area. *International Journal of Education and Evaluation*, 3, 12.
- Ugwu, A. A. (2009). *Towards inculcating of Chemistry practical skills in students teachers difficulties*. 50th Annual Conference of Science Teachers Association of Nigeria, 106-109.
- Ugwuanyi, A. A. (2015). Science process skills acquired by senior secondary school chemistry students. *A Masters Degree dissertation*. University of Nigeria, Nsukka.
- West African Examination Council (WAEC), (2017). Chief Examiner's report on students' performance in senior secondary school certificate Chemistry Examination. Lagos: *WAEC Sectional Report*, 2017.
- West African Examination Council (WAEC), (2019). Chief Examiner's report on students' performance in senior secondary school certificate Chemistry Examination. Lagos: *WAEC Sectional Report*, 2019.