Effects of Process-Based Instruction on Academic Achievement in Qualitative Inorganic Analysis among Secondary School Students in Katsina State

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Abstract
This study examined the Effects of Process-Based Instruction on Academic Performance in Qualitative inorganic Analysis among secondary school Chemistry Students in Funtua educational Zone of Katsina State Nigeria. The study employed quasi-experiment control group research design. The population comprises of 984 students in the study area. Out of which 103 students where sample using stratified random sampling technique. Three instruments were used for the study; namely Qualitative Inorganic Analysis Performance (QUIAPT) with reliability coefficient of 0.86, Group Assessment of Logical Thinking (GALT) with reliability coefficient of 0.80 and test of science skills acquisition (TOSSA) each instruments were duly Validated by experts and with a reliability coefficient of 0.86, 0.71 and 0.75 respectively were obtained using test retest method. The three research questions raised were answered using mean and standard deviation while the three research hypotheses were tested using t-test statistics at 0.05 levels of significance. Finding from the study revealed that there is significance difference between the performance of students taught qualitative inorganic analysis using Process-Based instruction and those exposed to lecture method. Based on the research findings, it was recommended among others that workshops, seminars and conferences should be organised for Chemistry teachers on the use of Process-Based instruction.

Keywords; Process-Based instruction, Learning Outcomes, Chemistry

Introduction

A long term goal of science education has been that students learn science concepts in a meaningful way and apply them in solving problems (Mari 2006, Reid, 2008 & Brisco 2013). Educators have emphasized that science concepts can only be meaningful if students understand the processes involved in generating them. Shaibu (2012) observed that the central purpose behind the new curriculum projects launched in Western countries in 1960s was basically aimed at presenting science to students the way science really is. Science education in the school was to provide students with adequate understanding of the nature and basic process of the scientific enterprise. The new curriculum according to him was designed to shift emphasis significantly from the old methods of presenting science as mere collection of facts and terms to be memorized by students to deeper understanding of the key concepts and fundamental principles of the subjects through appropriate use of the inquiry processes.

Many curriculum reform projects have been undertaken in Nigeria educational system to encourage students' participation in science teaching and learning such as Nigerian Integrated Science Project (NISP), Science Education Process Approach (SEPA) among others. However, science teaching remains primarily didactic, dominated by lectures, demonstration, text-book readings and memorization. Paul and Dantani, (2012) observed that many teachers teach Science using lecture method and avoiding the use of instructional methods that provides students first hand experiences and opportunity to solve problems; a situation that made teaching and learning boring and uninspiring to the students. Hence the need for teachers to try other students centered strategies like peer tutoring, cooperative learning, process-based instruction and computer assisted learning strategy among others.

Process based instruction is a strategy that simplify learning of science, it develop students' sense of responsibility in their own learning, and increase the permanency of learning. According to Njelita, (2009) and Ibrahim (2012) science process skills are transferable ability, appropriate to many science discipline, and reflective of the behaviour of scientists. They further classified the process skills into two: Basic Science Process Skills which involves observation, question raising, measurement, communication, classification and inference and Integrated Science Process Skills that requires controlling variables, defining terms operationally, formulating hypothesis, interpreting data, experimenting and formulating models. Both basic and integrated skills improve the thinking and reasoning abilities, enhanced problems solving and scientific investigation. Some Researchers; Ango (2002), Mari and Shaibu (2003), Danladi (2003) and Frazer (2004) indicated that process skills instructional strategy of teaching enhances students' academic Performance at the senior secondary school level. Similarly, Oloruntegbe and Odutunji (2003) opined that the often-perceived difficult and abstract concept in chemistry such as radioactivity, mole concept, stoichiometry, electrolysis, quantitative inorganic analysis among others can be clearly understood through process-based instructional which combines the psychomotor related skills of observing, and cognitive skills of reasoning.

Science classroom environment is characterized with students of varying pattern of thought. These occur due to variation in the individuals' information processing mechanisms as proposed by Piaget (cited in Gumel 2015). Some children process information through logical operation with concrete objects. Such children according to Mari (2001), are classified as concrete thinkers. Understanding of the concept of sedation and classification also manifest in these children. Similarly, Mari identifies some other children as formal thinkers. These set of children differs from the concrete reasoner in their ability

to carry out operations among symbols and think in abstraction (Keys, 1995). Research by Gumel (2007) indicated that both concrete and formal reasoners benefited from the process-based instruction. Students at the formal reasoning stage can formulate hypothesis, interpret data, carry-out experiment and make abstract inferences from data because of these students at this stage will perform and are expected to understand and participate in process-based instruction efficiently.

One of the demands in sciences in the 21st Century for the learner of science is the acquisition of scientific skills. The National Policy on Education (2007) The Federal Ministry of Education has tried to enhance the teaching of Science in most schools by introducing projects such as strengthening mathematics and sciences in secondary education, in order to improve performance (F.M.E,2007) Moreover Educational organization and agencies such as Science Teachers Association of Nigeria (S.T.A.N), Nigeria Educational Research and Development Council (N.E.R.D.C),Nigeria Teachers Institute (N.T.I) and Chemical Society of Nigeria (C.S.N) among others are committed to improvement of teaching and learning of science through workshops, conferences and seminars to science teachers. However, the performance of students in science generally and chemistry is not encouraging in the Senior Secondary Certificate Examinations as noted by the West African Examination Council (WAEC, Chief Examiners Report 2009 to 2018).

The poor performance of students in chemistry has continued to be of major concern to science educators. Olorundare and Sam, (2011) contend that students' mass failure in chemistry was attributed to the ineffective use of instructional strategy by teachers. This shows that teachers nowadays are unable to use instructional strategies that equip students with learning skills that ease their understanding.

The present study employed process-based instruction that is considered as one of the good strategies that make students to participate actively during lessons regardless of their reasoning ability as well as simplified acquisition of process skills by the students. The study therefore, investigated the performance of concrete and formal operational students in qualitative inorganic analysis to establish whether the formal operational learners are superior in performance or not when process-based instruction is used in teaching qualitative inorganic analysis concept in chemistry.

Objectives of the Study

Specific objectives of the study are to investigate the effects of;

1. Students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State.
2. Academic Performance of concrete and formal operational students exposed to qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua educational zone of Katsina State.
3. Acquisition of science process skills of students as a result of exposed to process-based instruction and those exposed to lecture method in Funtua educational zone of Katsina state.

Research Questions

The study attempt to answer the following questions:

1. What is the mean difference between academic performance of students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State?
2. What is the mean difference in academic performance of formal operational and concrete operational students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State?
3. Is there any mean difference in acquisition of science process skills between students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State?

Hypotheses

1. There is no significant difference between the academic performance of students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State.
2. There is no significance difference between academic Performance of concrete and formal operational students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State.
3. There is no significant differences in acquisition of science skills between students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State.

Methodology

Quasi-experimental research design involving pre-test and post-test control group design was used for this study. This involves two groups in which one group was used as experimental and the other as the control group. The same pre-test on Academic Performance and Reasoning Ability (OAP & RA) was administered to the chemistry students in the two groups before the treatment (X_1). This was to determine their performance in qualitative inorganic analysis and identify concrete and formal reasoners.

After treatment, both the students in experimental and control groups were post-tested on qualitative inorganic academic performance, and science process skills acquisition. The population of the study comprises of all co-educational public Senior Secondary Schools offering chemistry in Funtua Education Zone, Katsina-Nigeria. There are twenty-one coeducational public Senior Secondary Schools with population of nine hundred and Eighty four (984) Senior Secondary School year II students (SSSII) in the study area according to the Zonal Inspectorate of Education Funtua (ZIEF, 2018). Public schools were used because their organizational structure, condition of teaching and learning and mode of operation are relatively the same.

The sample of this study involves one hundred and three (103) SSII chemistry students drawn from the study population. Two local government areas were selected through balloting and from each local government area (L.G.A), one school was randomly selected to participate in the study. The sample subject for each school using intact classes of fifty-four (54), for experimental and forty- nine (49), for control groups respectively.

Three instruments were used to generate data for the study. These are: Qualitative Inorganic Analysis Academic Performance Test (QUIAAPT), Test of Science Process Skills (TOSPS), Group Assessment, of logical thinking (GALT), Qualitative Inorganic Analysis Academic Performance Test (QUIAAPT) instrument comprises of 40 multiple choice items developed by the researcher, The Test of Science Process Skills (TOSPS) consists of 25 multiple choice items designed to measure five skills (observation, measurement, inference, interpretation and hypothesis) and Group Assessment of logical thinking (GALT) was design to test the reasoning ability of the students (conservation reasoning, proportional reasoning, probabilistic reasoning, controlling variables, correlational reasoning, and combinational reasoning). The instrument was adopted from Mari (2001).

The validity of the instruments QUIAAPT, TOSPS and GALT was assessed by five experts drawn from the area of science education, Chemistry and educational psychology. All the suggestion offered by the experts were considered and effected before the production of the final draft of the instruments. The instruments were administered twice using test-retest method with a research period of two weeks interval in line with Sambo's (2008) recommendation. The results of the three tests were correlated using Pearson product moment correlation) a coefficient of 0.86, 0.71 and 0.75 was obtained for QUIAAPT, TOSPS and GALT respectively.

Results

Hypothesis 1

There is no significant difference between the academic performance of students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State.

Table 1: Result of the t-test analysis of Students Performance in Experimental and Control groups after instruction

Groups	N	Mean	S.D	Df	t	p	Decision
Experimental	54	24.81	4.85				
				101	8.69	0.01	Significant
Control	49	16.98	4.25				

Significant at P≤0.05; and df=101

Table 1 shows that the t-value of 8.69 was obtained and the P-value observed was 0.01 101 degree of freedom. The critical P-value of 0.01 is less than the alpha value of 0.05. This indicates that there was a significant difference in the performance between the academic performance of students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State. The significant difference was in favour of chemistry students exposed to qualitative analysis concepts using process skills instruction as revealed in their mean score.

Hypothesis 2

There is no significance difference between academic Performance of concrete and formal operational students taught qualitative inorganic analysis using process-based instruction

Table 2: Result of t-test means of Academic performance of Concrete and Formal Operational Students in the Experimental Group Exposed to Science

Reasoning	N	Mean	S.D	df	t	p	Decision
Formal	17	29.97	4.09				
				52	4.46	0.01	Significant
Concrete	37	23.78	4.45				

Significant at P≤0.05; and df=53

In Table 2, a mean of 29.79 was obtained for formal operational students and 23.78 for concrete operational students. The t-value observed was 4.69 and the p-value observed was 0.01 at 52 degree of freedom. The p-value of 0.01 observed was less than alpha value of 0.05. Thus, there is a significant difference in the academic performance of the students at the concrete operational stage and formal operational students in qualitative analysis due to exposure to process-based instruction. The significant difference is in favour of formal operational students as revealed in the mean scores. Therefore, the null hypothesis that states that there is no significant difference between academic Performance of concrete and formal operational students taught qualitative inorganic analysis using process-based instruction

Hypothesis 3

There is no significant differences in acquisition of science skills between students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina State.

Table 3: t-test comparison of the level of acquisition of science process skills of experimental and control Group

Gender	N	Mean	S.D	df	T	p	Decision
Experimental	54	16.09	4.04				
				101	3.35	0.01	Significant
Control	49	13.55	3.62				

Significant at P≤0.05; and df=101

Table 3 shows that the t-value of 3.35 was obtained and the P-value observed was 0.01 at the degree of freedom of 101. The critical P-value of 0.01 is less than the alpha value of 0.05. This indicates that there was a significant difference in the acquisition of science process skills of students taught qualitative inorganic analysis using process-based instruction and those taught the same concepts using lecture method. Thus, null hypothesis that states, There is no significant differences in acquisition of science skills between students taught qualitative inorganic analysis using process-based instruction and those exposed to lecture method in Funtua Educational Zone of Katsina state. The significant difference was in favour of students exposed to qualitative analysis concepts using process skills instructional strategy as revealed in their mean score.

Discussion of Findings

The findings in Tables 1 revealed a computed t-value of 8.69 and the p-value of 0.01 observed at degree of freedom of 101. It was concluded that since the critical p-value of 0.01 is less than the alpha value of 0.05, there is significant difference between the performances of the students in experimental and the students in the control groups in favour of experimental group. A significant difference implies

rejection of the null hypothesis which means the significant difference is in favour of experimental group. These findings are in supports of research findings of Mari (1994) and Ango (2001). Mari (1994) finding revealed that there is significant difference in the understanding of science process as expressed by students in the experimental and control groups in basic science concepts. Ango (2002) who discover that students taught using process skills instruction performed significantly better than those taught using lecture method.

From the findings in Table 2 revealed a computed t-value of 4.69 and the p-value of 0.01 observed at degree of freedom of 52. It was concluded that since the critical p-value of 0.01 is less than the alpha value of 0.05, there is significant difference between the performances of the students at formal stage and the subjects in the concrete stage in favour of formal stage. A significant difference implies rejection of the null hypothesis. Thus, null hypothesis that states that there is no significant difference between the performances of students in concrete operational stage and students in formal operational stage exposed to qualitative analysis concepts using process-based instruction and those taught the same concepts using lecture method is hereby rejected. The significant difference is in favour of formal operational stage students. The reason for the difference was because the formal operational reasoned have acquire higher order thinking skills and ability to reason in abstraction and are able to learn chemistry concept which are abstract better as pointed by Mari, (2001). This finding agrees with that of Damon (1984) and keys (1995) where formal reasoners were found to perform significantly better than the concrete reasoners in their ability to carry out operations among symbols and thinking in abstraction.

The findings in Tables 3 revealed a computed t-value of 3.35 and the p-value of 0.01 observed at degree of freedom of 101. It was concluded that since the critical p-value of 0.01 is less than the alpha value of 0.05, there is significant difference between the level of science skills acquisition of the students in experimental and those in the control groups in favour of experimental group. A significant difference implies rejection of the null hypothesis. Thus, null hypothesis that states that there is no significant difference in the level of acquisition of science process skills of students exposed to qualitative analysis concepts using process-based instruction and those taught the same concepts using lecture method is hereby rejected. The significant difference is in favour of experimental group. The reason for the difference was attributed to the ability of process skill instructions to allow students to participate actively in the lesson. This finding was supported by the works of Nwosu and Okeke (1995), Danladi (2003), and Oloyede (2012) who in their separate reports confirmed that there is significant difference in the levels of acquisition of science skills among students in science concepts due to exposure to process skills instruction compared to students taught the same science concepts using conventional teaching Method.

Conclusion

Based on the findings of this study, the following conclusions were drawn, Process-based instruction is more effective strategy for teaching the concepts of qualitative analysis to secondary school students. Formal operational students exposed to qualitative analysis using process-based instruction benefited more than the concrete operational students. Process-based instruction appears to promote students level of acquisition of science process skills in learning of qualitative analysis concept among senior secondary school students in Funtua Educational Zone of Katsina State.

Recommendations

Based on the findings, the following recommendations were made:

1. The use of Process-based instruction in teaching chemistry should be encourage by stake holders in the education industries at both federal and state ministries of education and other relevant agencies like STAN, NERDC among others. This can be achieved through periodic seminars and workshops to teachers on how to use Process-based instruction for teaching chemistry.
2. Curriculum Planners should examine the effect of Process-based instruction and recommend it for use in translating the curriculum at the classroom level where appropriate.

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