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EFFECTS OF FOUR INSTRUCTIONAL APPROACHES ON STUDENTS' ACADEMIC ACHIEVEMENT AND COGNITIVE ATTAINMENT IN PRACTICAL CHEMISTRY IN RIVERS STATE

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Abstract
The study investigates the effects of four instructional strategies on students' cognitive attainment, and performance of students practical skills in practical chemistry, specifically on Stoichiometry and Chemical Reactions. School location and parental supportiveness served as moderator variables. A pretest, post-test, control group, quasi-experiment with 4x2x2 factorial design was used. A total of 584 chemistry students from secondary schools in Rivers State of South-South Nigeria participated. Three hypotheses were tested. Nine instruments, including four stimulus instruments, were used and data analyzed with Analysis of Covariance and Sheffe posthoc test. There is a significant main effect of treatment on students' cognitive attainment ($F_{(2,571)}$= 161.941; $p<0.05$) and performance in practical skills (F(2,571 =78.45; $p<0.05$). Students exposed to guided inquiry with/without demonstration strategies achieved better than those exposed to demonstration and conventional strategies. School location had a significant main effect on student cognitive attainment (F (2,571) = 50.60; $p<0.05$) and performance in practical skills (F (2,571) = 16.62; $p<0.05$). The interaction effect of treatment, school location and parental supportiveness was not significant on the cognitive attainment in practical chemistry. The teaching and learning of practical chemistry seem to be most favoured by the use of guided inquiry, however guided inquiry could be supplemented with demonstration since the strategy was also an effective treatment.

Keywords: Instructional Approach, Student Academic Achievement, Cognitive Attainment, Practical Chemistry

Introduction

Chemistry is a core science subject at the senior secondary school level. Students need a minimum of credit pass in the subject before admission into tertiary institution to read most science-related courses in medicine, pure science, agricultural, engineering and another allied course. Chemistry, a central science subject deals with the complete description of matter, its learning tools required that students possess adequate knowledge and have the ability to exploit the physical world as scientists usually do (Yusuf 2015). Studies have been conducted, both outside in the shores of Nigeria to explain students' underachievement in chemistry. In this studies as observed by Lawrennze, et al., (2008). The most recurring factor is the influence teaching strategy technique teachers used to teach a secondary school. The revised senior secondary school chemistry curriculum in Nigeria, for SS1 - 3, identified contemporary development worldwide and consequently organised the content around four themes. These are the chemical world; chemistry and environment, and chemistry and industrial and chemistry and life (Federal of Education 2009). It was also always suggested that there should be a Paradigm shift from dispensing contact information as a body of facts to the use of problem-solving in teaching and learning of the subject. To achieve this and for successful implementation of the curriculum also focus on practical activity with emphasis on local and available materials, such that the spirit of enquiry method embedded in the students, curriculum, guided discovery approaches are recommended as the effective instructional approaches to be used by teachers (Yusuf 2015). McBrideet et al.,

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(2004) had observed that with a view to science teaching and learning, science educators globally have been promoting enquiry and science for some decades.

Research has indicated that chemistry students are not usually exposed to practical aspects of the subject and thus could not concretise their learning experience in the subject. Hodson (1998) identified a motive for employing practical works in school science. Three of which were to develop manipulative skills (performance skills) to elucidate theoretical work that can aid comprehension and to our rules and maintenance of the subjects. Some teaching strategies for science subjects have been investigated by scholars, these include the use of an analogy in pictorial representation (Abiona 2001), Inquiry method (Their & Daws 2001) and project-based instructional strategy (Moti & Barrizal 2002), concept mapping and problem-solving. Akuche (2008) investigated the effects of guided enquiry and demonstration methods in a physics lesson. Other are games-based learning(Ogunmola 2004), Interactive-Engagement and analogy enhanced (Abdulwahab 2014) and the use of multiple representations in the understanding of chemistry concepts (Yusuf 2015). Despite these, there is a dearth of information on the effects of industrial strategies like query and demonstration methods and on how these strategies might be used to influence student learning outcomes and practical chemistry.

Learning sciences is beyond acquiring scientific knowledge; it includes the acquisition of cognitive skills such as science process skills. This is important in whatever method of teaching science and it is during work for critical thinking and enquiry and sciences. Ergul et al (2011), citing Harlen (2000) submits that when students are made to acquire science process skills, it also prepares them as future scientists since they also acquire scientific literacy and this helps them to use science information in their personal, social and global life on daily basis. Activities such as the gathering of information on organisation communication and interpretation of observation can assist in the development of skills like identification manipulation, observation, measurement, understanding concepts, promoting a positive attitude and providing opportunities for students success.

Science teachers use several methods in presenting scientific information, principles of skills to the students. These include lectures, projects, laboratory investigation, individualized, field trips, demonstrative, discovery and discussion methods. This thus calls for a shift of emphasis on teaching science in the traditional way where contents and factual acquisition of knowledge is the goal, to the more pragmatic way where the learning is involved actively by doing. Numerous studies have shown that family, home environment and parental aspiration have a great influence on the learning outcome of the studies. Parenting supportiveness in-home background variables. parental support here includes the provision of material necessary for learning, financial and moral support.

School location is another variable and this product and is a view in terms of the city (urban) and (rural). A series of studies have investigated the importance of location influencing learning outcomes. Parental support, which is one of the home background variables in this study, included the provision of material necessary for learning, financial and moral support. How children do in school is a function of parenting support; it included that parents' support has a significant positive effect on children and across races, although the effect is greater for some groups of students than others (Jeynes (2005a; 2005b).

Statement of Problem

This study is designed to provide empirical data on the effects of instructional strategies such as Guided inquiry with demonstrations, Demonstration approaches and conventional approaches on students and learning outcomes (cognitive attainment, and performance of practical skills) in practical chemistry specifically in the teaching of Stoichiometry and Chemical Reactions. It also establishes the effect of the variables (school location and parental supportiveness) and their interaction on the learning outcomes.

Research Questions

1. What is the relative effect of guided inquiry with and without demonstration, and demonstration on the cognitive attainment of students in practical chemistry?
2. What is the relative effect of guided inquiry with and without demonstration, and demonstration on student performance in practical chemistry?

Hypotheses

Based on the problem the investigators would test the following null hypotheses

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Ho1: There is no significant main effect of
- (i) Treatment
- (ii) School location
- (iii) Parental supportiveness

On students
- (a) Cognitive attainment in practical chemistry
- (b) Performance of practical skills in practical chemistry

Ho2: there is no significant interaction effect of
- (i) Treatment and school location
- (ii) Treatment and parent supportiveness
- (iii) School location and parental supportiveness

Ho3: there is no significant interaction effect of Treatment, school location and parental supportiveness on students'
- (a) Cognitive attainment in parental chemistry
- (b) Performance of practical skills in practical chemistry.

Materials and Methods

The study adopted a 4 x 2 x 2 pretest-postest control group design in Quincy experimental setting. For chemistry classes were randomly assigned to three experimental and control groups of the design allows for the determination of the effect of each independent variable.

All senior secondary two (SS2) students of chemistry in public schools in South Western Nigeria constituted the target population. A multi-stage sampling technique was adopted for the research. This includes simple random sampling to select twelve local government areas. Purposive sampling was used to select a school from each of the twelve selected LGAs. Eligible schools should have functional laboratories, be equipped with electricity materials, have at least a graduate chemistry teacher, has been registering students for the West African School Certificate for at least five years. All the 584 students of the twelve (12) classes in the selected schools made up the study sample.

Four stimulus instruments were used to administer treatments in the study. These are
- (i) Laboratory manual for treatment I (guided Inquiry without Demonstration Approach)
- (ii) Laboratory for manual for treatment II (guided Inquiry without Demonstration Approach)
- (iii) Laboratory for manual for treatment III (guided Inquiry without Demonstration Approach)
- (iv) Laboratory for manual for treatment IV (The Conventional Approach) One General Teacher's Instructional Guide

Each of the stimulus instruments had three double period lesson plans on topics in Stoichiometry and Chemical Reactions. A double period chemistry lesson in Nigeria is a 2x40 minutes lesson expected to be taken in the laboratory.

Three other instruments were also used to gather data from Chemistry students who participated in the study. These are:
- (i) Parental supportiveness scale (with Cronbach alpha estimate or r = .68)
- (ii) Test of Knowledge of Chemistry Practical (with test-retest reliability of .72)
- (iii) Test of Practical skills in Chemistry (with test –reliability of 0.75)

Analysis of Covariance (ANCOVA) and Scheff post hoc was used to analyse the data gathered.

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Results

Table 1: Summary of ANCOVA of Post-test of Students Scores of Cognitive Attainment in Chemistry by Treatment, School Location, and Parental Supportiveness with Pre-test scores as Covariates.

Sources of Variance	Sum of squares	DF	Mean Square	F	p-value
Covariates pre-test	602.632	1	602.632	32.142	0.000*
Main Effects(combined)	6532.55	4	1633.113	81.418	.000*
Treatment Group	6317.038	2	58.909	161.94	.000*
School Location	86.075	1	86.075	5.120	0.042*
Parental Supportiveness	112.528	1	112.528	6.245	0.018*
2-way Interaction (combined	159.188	5		2.501	.159
Treatment x school Location	21.073	2	10.51	0.530	0.572
Treatment x Parental Supportiveness	131.608	2	65.84	3.291	0.018*
Location x Parental Supportiveness	0.198	1	23.198	0.010	0.921
3-way interactions: Treatment x School Location x Parental Supportiveness	36.941	2	16.94	0.931	0.398
Explained	7151.833	12	595.0	29.804	.000*
Residual	9578.631	571	16.776		
Total	16730.464	583	28.697		

KEY * = Significant at p<0.05

Table 2:Multiple Classification Analysis of post-test of Cognitive Attainment in chemistry scores according to treatment, School Location and parental Supportiveness. Grand Mean = 15.50

Treatment + Category	N	Unadjusted deviation	Eta	Adjusted Independent covariation deviation	For	Beta and
Treatment Guided-inquiry without demonstration	116	2.44		2.62 2.37 -4.84		
Guided-inquiry with demonstration	19512.39	0.58			0.62	
Demonstration	115	2.31	0.54			
Control	158	-4.73				
School Location Urban	300	-0.87	0.15	-0.37	.06	
Rural	284	0.89		0.38		
Parent Supportiveness			0.15		0.08	
Low	305	-0.84		-0.47		
High	279	0.89		0.50		

Multiple R^2= 0.425

Multiple R = 0.652

The combination of all the factors, (Table 2) would explain 42.5% of the variation in students' cognitive attainment in practical chemistry. The remaining 57.5% can only be accounted for by some other factors not included in this study.

Table 3: Scheffe Multiple Range Tests of Cognitive attainment by Treatment

Treatment	N	X	Guided inquiry without demonstration	Guided inquiry with demonstration	Control
Guided inquiry without demonstration	193	57.67			*
Guided inquiry without demonstration					
Control	158	40.42	*	*	
Demonstration	115	50.47			

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Table 4: Summary of ANCOVA of post-test scores on students' performance skills in chemistry by Treatment, school location and parental supportiveness

Source of Variation	Sum of squares	DF	Mean Square	F	S
Covariates Pre-test on students' performance of practical skills	601.852	1	601.852	30.123	0.000
Main effects (combined)	6532.357	4	1633.09	78.408	0.000*
Treatment groups	6175.35	2	3087.52	147.857	0.000*
School location	83.672	1	83.672	4.140	0.502
Parental supportiveness	116.714	1	116.714	5.236	0.019*
2-way interaction (combined)	132548.770	5	26509.754	169.874	.000*
Treatment x school location	2373.469	2	1186.735	56.034	0.017*
Treatment x parent supportiveness	42203	2	21101	.996	.372
School location x parent supportiveness	435.378	1	435.378	34.265	.000*
3-way interactions Treatment groups x School location x Parental supportiveness	38.494	2	19.25	0.824	0.378
Explained	7132.804	12	594.40	27.924	0.000
Residual	9592.613	571	16.80		
Total	16725.42	583	28.69		

TABLE 5: Multiple Classification of Analysis of Post-test performance of practical skills scores according to Treatment, School Location and Parental supportiveness on students.
Grand Mean = 53.80

Treatment + category	N	Unadjusted Deviation	Eta	Adjusted for Independent and Covariates Deviation	Beta	
Treatment						
Guided Inquiry Without Demonstration	116	0.34		0.44		
Guided inquiry with Demonstration	195	0.41		1.35		
Control	158	-0.68	0.31	-1.93		0.32
School Location						
Urban	300	-0.08		-0.08		
Rural	284	0.07	0.02	0.09		0.02
Parental Supportiveness			0.09			
Low	305	-0.36		-0.14		
High	279	0.41		0.14		0.4
Demonstration	115	0.46				

Multiple R2 = 0.454
Multiple R= 0.674

Combination of all the factors, (Table 5) would explain 45.5% of the variation in students' performance skills in chemistry. The remaining 54.6% can only be accounted for by some other factors not included in this study.

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Table 6: Scheffe Post hoc Tests of performance of practical skills scores by Treatment

Treatment	N	X	Inquiry Without Demonstration	Inquiry + Control Demonstration
53.8				
Guided inquiry without Demonstration	116	55.74		
Guided inquiry with Demonstration	195	56.32		*
Control	158	49.34	*	
Demonstration	115	48.75		

Research question one:

The posthoc multiple classification Analysis and (Table 2) and Scheffe Multiple Range test (Table 3) on the ANCOVA, show the relative mean scores of students in cognitive attainment in practical chemistry in the four different groups. The table also shows that the highest mean was observed from the students exposed to the guided inquiry without demonstration Mean = 58.40, followed by that of the students exposed to guide discovery with demonstration, Mean= 57.46. The mean score of the students in the control class was least, Mean = 40.42.

Research question two

Similarly, the Post-hoc multiple classification Analysis and (Table 5) and Schffe Multiple Range test (Table 6) on the ANCOVA, show the relative mean scores of students performance in practical skills in different groups. Students exposed to guided inquiry with demonstration had the highest mean score X = 56.32, followed by those exposed to Demonstration who had the least mean score of Mean = 48.75.

Ho 1

(i) There was a significant main effect of treatment on:
- (a) Cognitive attainment in practical chemistry (F4, 584) = 161.94 (H)1 is thus rejected at .05 level of sig.
- (b) Performance in practical skills in practical chemistry (F2, 572) 147.857 (Ho1b is also rejected at .05 level of sig.

(ii) (a) The main effect of school location on cognitive attainment in practical chemistry was significant (F1, 572) = 5.120 (*Ho* 1: 2a is rejected at .05 level of sig.

(b) The main effect of school location on performance in practical skills practical chemistry was significant. (F1, 572)=4.140) (Ho1: 2a is rejected at .05 level sig.

(iii) (a) The main effect of parental supportiveness on cognitive attainment in practical chemistry was significant. (F4, 584) = 6.245 (*Ho1*: 2b is rejected at .05 level sig.

(c) There was a significant effect of parental supportiveness on performance in practical skills in practical chemistry. (F1, 572) =5.236) (Ho2:1a is not rejected at 05 level or sig.

Ho 2

(i). (a) The interaction effect of treatment and school location on cognitive attainment in practical chemistry was not significant (F1, 572) = 0.530) (Ho2: 1a is not rejected at .05 level or sig.

(b) Interaction effect of treatment and school location on performance on practical skills in practical skills in practical chemistry was significant. (F1, 572) =56.034) (Ho2:1b is rejected at .05 Level or sig.

(ii) (a) there was a significant interaction effect of treatment and parental supportiveness on cognitive attainment in practical chemistry (F1, 572) = 3.291) (Ho2:2a rejected at .05 Level of sig.)

(b) There was no significant interaction effect of treatment and parental supportiveness on Performance in practical skills in practical chemistry (F1, 572) = 0.996) (Ho2:2b not rejected at .05 level of sig)

(iii) (a) there was no significant interaction effect of school location and parental supportiveness on Cognitive attainment in practical chemistry (F1, 572) = 34.235) = 0.1010) (Ho2:3a is not rejected at .05 Level of sig

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(b) There was significant interaction effect of school location and parental supportiveness performance in practical skills in practical chemistry (F1, 572) = 34.235) (Ho2:3b is not accepted)

Ho3

(i) The three-way interaction effect of treatment, school location and parental supportiveness was not significant in Cognitive attainment in practical chemistry (F1, 572) = 0.931) (Ho3:1a is not rejected at .05 Level of sig)

(ii) The three-way interaction effect of treatment, school location and parental supportiveness was not significant on performance in practical skills in practical chemistry. (F1, 572) = 0.824) (Ho3:3b not rejected at .05 Level of sig)

Discussion

The study reveals that there is a significant effect of the three treatments on the cognitive attainment and performance skills in practical chemistry in senior secondary schools. The guided inquiry with or without demonstration and demonstration are effective teaching strategies that can enhance the learning of practical chemistry. This is because each of the strategies allows the students to have the opportunity of being involved and go through the study of practical chemistry in an activity-based setting as stipulated even by the curriculum of chemistry. This result corroborates the conclusion of Kalu (2001) in his review of studies involving laboratory work, that though lecture, demonstration and laboratory teaching methods appear to be equally effective in transmitting science content; laboratory experiences are more effective at providing students with skills needed to work with the equipment. Also, Ibe and Nwosu (2003) while supporting the age-long view that no single instructional model or approach is best for all learners or situations, however, submit that effective science teaching should be laboratory centred, activity-oriented rather than textbook learning.

Considering the direction and magnitude of the relative effects of the instructional strategies on the learning outcomes of practical chemistry in students, Table 3 shows that the higher mean score was obtained by the group of guided inquiry with demonstration than the demonstration group and lastly, the control group. The inquiry teaching strategies make students apply in-depth reflection of prior knowledge of practical chemistry, provide more opportunities for scientific reflection and this makes students have more cognitive attainment, and consequently able to acquire more performance skills in practical chemistry. Ibe and Nwosu (2003) using a set of 150 senior secondary biology students in some schools in Nsukka, Nigeria Considered the effect of guided inquiry and demonstration on science process skills. They concluded that guided inquiry groups scored higher than the demonstration and conventional groups. A demonstration can play an important role in enhancing learning outcomes if it is well designed and well implemented. Students should be incited to hypothesize, speculate, interpret and apply what is being illustrated in demonstration the physical world (real life) and be encouraged to be participatory.

There was a significant main effect of parental supportiveness on cognitive attainment in practical chemistry and performance skills in practical chemistry. Parental supportiveness comes in form of providing necessary materials, financial and moral support; this, to a large extent, makes students have sound and mental alertness to their studies and this invariably leads to high cognitive attainment of school subjects including chemistry especially practical chemistry. Onabanjo (2000) and Apara (2005) working on Mathematics and Social Studies respectively found a significant main effect on achievement in the corresponding subjects. Davis-Kean (2005) while examining the relationship between parental education and income about children's academic achievement through parents ' beliefs and behaviours found significant relationships among the variables. The study involved 868 students with an age range of 8-12 years, and he was able to show that parental education and income correlated highly with academic achievement through parents ' beliefs and behaviours.

Effects of school location were recorded on cognitive attainment in practical chemistry though there was no three-way interaction effect of treatment, school location and parental supportiveness on cognitive attainment, and performance skill in practical skills. It is easier to make the remarkable impact of innovative instructional strategy on the cognitive, affective and psychology domains among students from urban areas in practical chemistry because such students are good at availing themselves the opportunity to perform better in a core and central subject to their

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career aspiration. For rural students, the teacher would need to go the extra mile before the students can appreciate the new methods. Bartholameou (2002) provided an explanation to this in his submission that students in rural communities are usually looked down because of their attitude to schooling, lower levels of education, poor behaviour, and lack of academic ability. These negative discourses, according to the researcher exist among teachers, parents and the community. Ndukwu (2002) and Orji (2004) also claim that there is an indirect correlation between school location and academic achievement. Isuigo - Abanihe and Labo Popoola (2004) however revealed that school location had a significant effect on students 'achievement in the English language.

Conclusion

This study has revealed that the inquiry approach is more effective than the demonstration method in teaching practical chemistry, chemistry teachers are therefore enjoined to review their approaches to imbibe inquiry method while teaching to ensure higher cognitive attainment and acquisition of practical skills in chemistry practical. There were significant main effects of both school location and parental supportiveness on cognitive attainment and acquisition of practical skills in practical chemistry irrespective of the four methods of instruction adopted. The two-way and three-way interaction effects of the moderating variables are however not of any regular pattern.

Further studies

Further studies may be organised by developing other teaching strategies which may be experimented on chemistry and even other science subjects. Again school type public, private or federal government schools may be investigated.

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