

# Effect of Procedural Knowledge Instructional Technique on Chemistry Students' Practical Skills Acquisition in Qualitative Analysis

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## Abstract

The study investigated the effect of procedural knowledge instructional technique on students' practical skills acquisition in qualitative analysis. The population of the study consisted of 2,134 SS2 chemistry students in Nsukka Education Zone, Enugu State. The sample size for the study was 237 students drawn from eight schools out of fifty – eight public schools in the area. The design of the study was non - randomized control group quasi – experimental design. Two research questions and three hypotheses guided the study. Mean and standard deviation were used to answer the research questions while the hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Findings showed that: Procedural knowledge instructional technique (PKIT) enhances acquisition of science practical skills necessary for science and good performance in qualitative analysis in chemistry. It was therefore, recommended that teachers of chemistry should be encouraged to use PKIT in teaching qualitative analysis. In so doing, the practical skills acquisition of students in qualitative analysis in chemistry could be enhanced irrespective of school location.

**Keywords:** *Procedural Knowledge Instructional Technique, Conventional Demonstration Strategy, Skills Acquisition, Qualitative Analysis. School Location.*

## INTRODUCTION

Procedural knowledge instructional technique is an innovative technique that guides teacher's action during practical work in qualitative analysis in chemistry. It is a problem solving technique. Procedural knowledge instructional technique is of paramount importance to a teacher's effective delivery of practical lesson in qualitative analysis (Jokar et al.i, 2012). For the purpose of this study, Procedural knowledge instructional technique is a structured and systematic technique to qualitative analysis in order to characterize chemical samples and identify their constituent ions. Procedural knowledge instructional technique is to follow a consistent sequence of carrying out qualitative analysis in order to arrive at the correct identification of the qualities of the substance being analyzed. Procedural knowledge instructional technique involves assisting individuals to acquire skills and knowledge so that they are able to perform a task to a specific standard. In procedural knowledge instructional technique, the outcomes to be achieved are clearly stated so that students may know exactly what they have to do. A teacher knows what training or learning to be provided. The emphasis on procedural knowledge instructional technique is on doing rather than just knowing. Teachers were advised to adopt instructional techniques that can bring about attitudinal change and skills acquisition by learners to facilitate problem solving in the subject. These techniques were described as techniques of activity, enquiry and discovery which are cognitive, affective and

psychomotor in orientation. Such techniques arouse and genuinely promote the practical skill acquisition in qualitative analysis in chemistry.

Procedural knowledge can be measured using the science process skills (Basic scientific process skills and integrated scientific process skills). However, emphasis on students' mastery of science process skills should be regarded as an important element in the process of teaching and learning of qualitative analysis in chemistry. Chemistry is essentially a practical oriented subject which demands proper exhibition of science process skills acquisition and concept for effective interpretation of existing phenomena. The importance of chemistry practical skills cannot be over stressed. Chemistry practical skills are science process skills. Science process skills are those skills which scientists employ in data gathering, transformation and interpretation in order to arrive at conclusions. The science process skills (SPS) are cognitive, psychomotor and affective skills which scientists employ in problem identification, objective inquiry, data gathering, transformation, interpretation and communication. Science process skills may be described as abilities which can be developed by experience and which are used in carrying out mental operations and physical actions. Studies by Muhammed (2014), Igboegwu and Egolum (2010), Okoli (2006) and Njoku (2005) asserts that when students acquires the science process skills of observing, measuring, questioning, designing experiments, interpreting data etc., such a person becomes specially equipped with the tools required for scientific inquiry or problem-solving as well as ability to use these skills in the laboratory for a variety of investigations. Laboratory skills are therefore synonymous in many ways with science process skills. Hence instructional strategies that enhance the acquisition of science process skills also enhance the laboratory skills acquisition (Eilks & Hofstein, 2013). The use of procedural knowledge instructional technique may enhance the acquisition of such science process skills.

so it is essential for teachers to have a good understanding of these skills ( Anaekwe & Ezeuchu, 2015). The use of procedural knowledge instructional technique may enhance the acquisition of such science process skills. Qualitative analysis may be perceived to be difficult by students. This is because most of the times, chemistry teachers do not teach it effectively. Qualitative analysis should not be difficult to students if the teachers have adequate procedural knowledge and skills for teaching the students for the students to achieve positively in chemistry.

Evidence of fluctuating and unsatisfactory poor achievement in chemistry at Senior Secondary Certificate Examination has been shown by examiners report. Data obtained from West African Examination and also from the result of the years 2007 to 2016 confirmed students' poor achievement. The WAEC Chief Examiners reports have consistently indicated that Nigerian students perform very poorly in practical chemistry examinations, especially in the aspect of qualitative analysis. Teaching practical skills in qualitative analysis using conventional demonstration strategy had failed us. Conventional demonstration strategy (CDS) as a teaching strategy refers to the visual presentation of the action and activities or practical work related to the facts and principles of a delivered lesson by the teacher in the classroom, aiming to facilitate the task of teaching and learning (Deborah et al., 2011). Demonstration strategy of teaching serves as a model laboratory instruction but conventional demonstration strategy is teacher centered. This is because in conventional demonstration strategy, the teacher does whatever the students are expected to do at the end of the lesson by showing them how to do it and explaining the process to them. The teacher must be sure he/she can do what he/she is supposed to demonstrate. Traditionally, demonstration can be used for introduction as in set

induction during lesson and in practical work, but demonstration as a teaching strategy had not been effective in yielding the desired results (Ochu, 2010). There may be other factors such as school location.

School location may be a contributory factor. The location of schools has a lot to do with how a child learns in schools. The location of schools simply refers to where the school is located, whether in urban or rural area i.e. rural or urban environment. These two environments are quite distinct in socio-economic terms. Location is the environmental condition around a school which for the purposes of this study refers to urban and rural environment which may affect his/her practical skills acquisition and interest. Urban environment can be conceptualized as that which has high population density, containing a high variety of beautiful common place views, whereas rural environment is characterized by low population density containing a low variety and isolated place views, (Osokoya & Akuche, 2012). Series of studies have investigated the importance of school location in influencing learning outcomes and found out it could affect students positively or negatively especially with a meager distribution of teachers in the rural schools when compared with the urban schools.

The number of teachers in rural schools is usually low because teachers do not readily accept postings to rural areas, because rural communities are characterized by low population, monotonous and burdensome life. Most teachers prefer to stay in the schools in urban areas because of the benefits and comforts of the city which include good roads, satisfactory means of communication, availability of books and teaching materials, etcetera. Highly qualified teachers also prefer to stay in city schools. This however, affects the schools in the rural areas. Most schools in rural areas lack qualified teachers who can handle subjects like chemistry especially practical. This is likely to affect chemistry practical negatively. Practical chemistry activities is likely to be affected negatively in the rural areas because of lack of qualified teachers and in urban areas because of overcrowding. This may affect practical work and hence students' learning outcomes. Because of the large class population, students may not be exposed to practical classes as often as they should. The practical work is either not done at all or done in a haphazard way to 'fulfill all righteousness' and not to enhance learning. In such a situation, the teacher as well as the students' attitude may be affected negatively unless there is adequate number of materials (which is very rare) available at their disposal. Okonkwo, (2012) among others reported that students in the urban area performed better than those in the rural area while Njoku and Akwali (2016) refuted the findings claiming that pupils in the rural area performed significantly better than their urban counterparts. However, in yet another development, Bosede, (2010) reported that there is no significant relationship between school location and student's practical skills acquisition. Therefore, this study investigated whether the use of procedural knowledge instructional technique enhanced practical skills acquisition in qualitative analysis in chemistry irrespective of school location.

The frequent students' mass failure in this aspect of the chemistry examination raised questions as to what the chemistry teachers teach and whether the teachers themselves possessed procedural knowledge and skills for teaching students. If chemistry teachers lack procedural knowledge, then they cannot teach their students practical procedures in qualitative analysis. Can the procedural knowledge instructional technique as an innovative technique enhance practical skills acquisition in qualitative analysis? Therefore, the problem of this study put in question form is: What is the effect of procedural knowledge instructional technique on chemistry student's practical skills acquisition in qualitative analysis.

## Research Questions

The study sought answers to these research question:

- 1) What are mean practical skills acquisition scores of students taught qualitative analysis using procedural knowledge instructional technique and those taught with conventional demonstration strategy?
- 2) What are the mean practical skills acquisition scores of urban and rural students in qualitative analysis?

## METHODOLOGY

The design of the study was non- randomized control group quasi- experimental design. Specifically; the study adopted the pre-test and post- test non – randomized control group design. The study was carried out in Nsukka Education Zone of Enugu State. Nsukka Education Zone is made up of Nsukka, Igbo – Etitu and Uzo – Uwani Local Government Areas (LGAs). The LGAs have 30, 16 and 12 government owned secondary schools respectively.

The population for the study comprised 2,134 SS2 Chemistry students (PPSMB, 2017) from 58 secondary schools in Nsukka Education Zone of Enugu State in 2017/ 2018 academic session. The population is heterogeneous. The sample size for the study was 247 chemistry students. Multistage sampling procedure which involved three stages was used to draw the sample size for the study. Purposive sampling technique was used to select twenty – two (22) out of the forty- eight (48) co- educational schools in the zone that qualified for the study which include that the schools selected must have SS2 students studying Chemistry, have Chemistry laboratory, have Chemistry teachers and the school must be willing to participate in the study. The twenty- two schools selected met the criteria specified. Proportionate stratified random sampling technique with balloting was used to select eight (8) schools out of twenty –two (22) schools from the zone according to each LGAs. Simple random sampling technique was used to assign four (4) schools for both experimental and control groups using intact classes.

Practical skills acquisition in Qualitative analysis rating scale (PSAQARS) was used for data collection. The Part One of PSAQARS consists of thirteen (13) essay items developed by the researcher after consulting literatures from past WAEC examinations and recommended textbooks and also references was made to the performance objectives for qualitative analysis as stated in the WAEC and NECO scheme Variables of work and also in SS2 Chemistry scheme of work which includes separation of mixtures. These thirteen (13) essay items served as a guide to the students during the chemistry practical activities in qualitative analysis. Part Two of PSAQARS also consisted of a 5- point rating scale with 43- items which had been grouped into eight clusters A – H skills categories. The skills categories are broad qualitative analysis practical skills which students of qualitative analysis were expected to develop at the end of practical chemistry instruction programme. These include: Conduct of Experiment, Manipulating Extraneous Variables, Measuring, Organization of Work Space, Safety Precautions, Observation, Acquiring Data and Recording of Data and Communication. The scale points include: Very Poor (VP) = 1, Poor (P) = 2, Fair (F) =3, Good (G) =4, Excellent (E) = 5. The PSAQARS served as the observation schedule for rating the performance of the students as they engaged in qualitative analysis practical activities.

In order to determine the reliability of the instrument, PSAQARS was trial tested using 64 SS2 students of a co-educational school in Obollo – Afor Education Zone having same geographical characteristics with the area of study. The data obtained from the trial testing of

the instrument was used to estimate the internal consistency of the instrument. The reliability coefficient of PSAQARS was estimated using Kendall Coefficient of Concordance and reliability coefficient of 0.70 was obtained.

Three (3) regular chemistry teachers who served as research assistants from each of the selected schools for the study were trained. At the end of the training, two (2) teachers were selected to serve as research assistants following their performance at the end of the training. The training was to drill them on the content, methodology and the use of the procedural knowledge instructional technique. The other research assistant functioned as a stand – by instructor. Research assistants were also selected and given training conventionally using demonstration strategy before the practical exercise since they taught the control group using the conventional demonstration strategy. The training lasted for 4(four) days. The chemistry teachers (research assistants) were separated on the basis of whether they were in experimental group or control group. Each group of teachers was trained in one place. Mean and standard deviation were used to answer the research question. The hypothesis was tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). The pretest scores were used as covariates to the posttest scores.

## RESULTS

**Table 1: Mean and standard deviation of student’s process skills scores taught using procedural knowledge instructional technique and conventional demonstration strategy**

Instructional Technique	N	x	SD	x	SD	Mean gain difference
Procedural Knowledge Instructional Technique	133	67.89	21.95	175.08	20.7	107.19
Conventional Demonstration Strategy	104	56.23	19.94	127.76	7.23	71.53

Result in table 1 showed that the experimental group taught qualitative analysis using procedural knowledge instructional technique had a pretest mean practical skills acquisition score of 67.89 with a standard deviation of 21.95 and a posttest mean score of 175.08 with a standard deviation of 20.70. The difference between the mean scores for the pretest and posttest for the group taught qualitative analysis using procedural knowledge instructional technique was 107.19. The control group taught qualitative analysis using conventional demonstration strategy had a pretest mean score of 56.23 with a standard deviation of 19.94 and a posttest mean score of 127.76 with a standard deviation of 7.23. The difference between the mean scores for the pretest and posttest for control group was 71.53. However, for each of the groups, the posttest means were greater than the pretest means with the experimental group having the highest mean gain. This is an indication that procedural knowledge instructional technique had more positive effects on students’ practical skills acquisition than the conventional demonstration strategy. In order to ascertain if the observed difference is real or an error variance occur the result was subjected to inferential testing.

**Table 2: Analysis of covariance (ANCOVA) of students overall practical skills score by group and teaching method**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Dec.
Corrected Model	140328.216 <sup>a</sup>	4	35082.054	155.488	0.00	
Intercept	480279.568	1	480279.568	2128.661	0.00	
Pretest	3271.468	1	3271.468	14.500	0.00	
Group	115397.961	1	115397.961	511.459	0.00	S

Gender	3368.195	1	3368.195	14.928	0.00	S
Group * Gender	2044.198	1	2044.198	9.060	0.00	S
Error	52345.050	232	225.625			
Total	5836489.000	237				
Corrected Total	192673.266	236				

S = Significant, NS= Not Significant at 0.05 level

The result in Table 2 shows that with respect to the significant difference in the mean practical skills scores of students taught qualitative analysis using procedural knowledge instructional technique and those taught with conventional demonstration strategy, an F-ratio of 511.45 was obtained with associated probability value of 0.00. Since the associated probability value of 0.00 was less than 0.05 set as benchmark, the null hypothesis ( $H_{01}$ ) which stated that there is no significant difference in the mean practical skills scores of students taught qualitative analysis using procedural knowledge instructional technique and those taught with conventional demonstration strategy is rejected. Inference drawn therefore is that, there was a significant difference in the mean practical skills scores of students taught qualitative analysis using procedural knowledge instructional technique and those taught with conventional demonstration strategy with those taught with procedural knowledge instructional technique having a higher mean in the posttest.

**Table 3: Mean and standard deviation of pretest and posttest practical skill acquisition scores of urban and rural students taught qualitative analysis using Procedural Knowledge Instructional Technique**

Location	N	Pre test		Posttest		Mean gain
		$\bar{x}$	SD	$\bar{x}$	SD	
Urban	147	57.92	21.14	146.41	27.15	88.49
Rural	90	70.71	20.69	167.22	26.14	96.51

Result in Table 3 shows that students from urban schools taught qualitative analysis had a pretest mean of 57.92 with a standard deviation of 21.14 and a posttest mean of 146.41 with a standard deviation of 27.15. The difference between the pretest and posttest mean for students from urban schools taught qualitative analysis was 88.49. The students from rural schools taught qualitative analysis had a pretest mean of 70.71 with a standard deviation of 20.69 and a posttest mean of 167.22 with a standard deviation of 26.14. The difference between the pretest and posttest mean for students from rural schools taught qualitative analysis was 96.51. The result of the study showed that for each of the groups, the posttest mean was greater than the pretest means with the students from rural schools having a higher mean gain. This is an indication that students from rural schools achieve higher when taught qualitative analysis than the students from urban schools. In order to ascertain if this observed difference is real or an error variance the result is subjected to inferential testing.

**Table 4: Analysis of covariance (ANCOVA) of students overall Practical Skills Acquisition Scores by location and method.**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Dec.
Corrected Model	136143.559 <sup>a</sup>	4	34035.890	139.685	0.00	
Intercept	425949.776	1	425949.776	1748.114	0.00	
Pretest	5056.290	1	5056.290	20.751	0.00	
Group	57810.597	1	57810.597	237.257	0.00	
Location	54.891	1	54.891	0.225	0.63	NS
Group * Location	1194.599	1	1194.599	4.903	0.02	S

Error	56529.707	232	243.663			
Total	5836489.000	237				
Corrected Total	192673.266	236				

S = Significant, NS = Not Significant at 0.05 level.

The result in Table 4 shows that with respect to the significant difference in the mean practical skills acquisition scores of urban and rural students in qualitative analysis, an F-ratio of 0.22 was obtained with associated probability value of 0.63. Since the associated probability value of 0.63 was greater than 0.05 set as bench mark, the null hypothesis ( $H_{02}$ ) which stated that there is no significant difference in the mean practical skills acquisition scores of urban and rural students in qualitative analysis is not rejected. Inference drawn therefore is that, there was no significant difference in the mean practical skills acquisition scores of urban and rural students in qualitative analysis.

## DISCUSSION

The American Association for the Advancement of Science (AAAS) has identified fifteen process skills of science. These are broadly classified into basic and integrative process (Anaekwe, 2010). The acquisition of these skills by students depends essentially on the strategic role of the chemistry teacher in structuring the teaching process. Therefore, the teacher's proficiency in effectively enriching classroom instructions via hands-on, activity-based, student centered and manipulative activities as well as utilizing efficacious instructional techniques has a lot of role to play in chemistry as a science subject. In chemistry practical the first nine of these process skills known as the basic processes include observing, classifying, comparing, communicating, using numbers, measuring, recognizing spatial relations, inferring and predicting. The later six process skills are referred to as the integrative processes. These include defining operationally, hypothesizing, identifying and controlling variables and interpreting data, experimenting, and using models.

Location is the environmental condition around a school which for the purposes of this study refers to urban and rural environment which may affect his/her practical skills acquisition and interest. Urban environment can be conceptualized as that which has high population density, containing a high variety of beautiful common place views, whereas rural environment is characterized by low population density containing a low variety and isolated place views, (Osokoya & Akuche, 2012). Series of studies have investigated the importance of school location in influencing learning outcomes and found out it could affect students positively or negatively especially with a meager distribution of teachers in the rural schools when compared with the urban schools.

The number of teachers in rural schools is usually low because teachers do not readily accept postings to rural areas, because rural communities are characterized by low population, monotonous and burdensome life. Most teachers prefer to stay in the schools in urban areas because of the benefits and comforts of the city which include good roads, satisfactory means of communication, availability of books and teaching materials, etcetera. Highly qualified teachers also prefer to stay in city schools. This however, affects the schools in the rural areas. Most schools in rural areas lack qualified teachers who can handle subjects like chemistry especially practical. This is likely to affect chemistry practical negatively. The location of schools has a lot to do with how a child learns in schools. The location of schools simply refers to where the school is located, whether in urban or rural area i.e. rural or urban environment. These two environments are quite distinct in socio-economic terms. Differentiation between

urban and rural areas is demographically done by the government offices of Regional planning and development. According to AEFRA (2005), there is no universally accepted way to classify the urban/rural environment. He further reported that the following criteria; population density, economic specialization, human resources and skills, land cover, spatial dimensions of social life and agriculture could be used for the classification. He saw agriculture as an important determinant factor for defining the rural area. The people in the rural localities are predominantly subsistent farmers with lower skilled and educated labour force, while the urban area is cosmopolitan in nature, characterized by rapid socio-economic and cultural flux. The rural environment is traditional and homogenous in socio-economic and cultural terms. Urban areas are those with social facilities while rural areas lack social facilities like electricity, pipe borne water supply, tarred roads etc. These criteria will be adopted in this study. Population density, economic status and social differentiation are equally low in these rural areas.

However, the specific problems of teaching chemistry in urban and rural environments and whether urban students achieve significantly better than their rural counterparts in qualitative analysis have not been adequately investigated. According to Nbina and Obomanu (2011), Federal and State Government in Nigeria had been making concerted efforts to improve the educational system in the rural areas using certain education management commissions to ensure that qualified specialist teachers and facilities are sent to rural schools. These efforts by the Government notwithstanding, secondary schools in rural areas appear to be disadvantaged in areas of infrastructure. The fact is that most rural secondary schools are comparatively new and they are not as well equipped as most urban secondary schools. Furthermore, teachers are known to prefer postings to urban than in rural areas.

Evidence from literature on the influence of school location on students' performance has conflicting results (Ezeudu & Obi, 2013; Onah, 2011; Owoeye & Yara, 2011; Bosede, 2010; and Njoku, 1997). Ezeudu and Obi, (2013) indicated that schools in urban areas have electricity, water supply, more teachers, more learning facilities and infrastructure. Onah (2011) also indicated that schools in the urban areas performed more than schools in the rural areas in science subjects. Specifically, Owoeye and Yara (2011) showed in their studies that schools in urban locations had better performance than their rural counterparts in chemistry. Osuafor (2001) reported in favour of the rural students, while Bossede, (2010), showed that school location has no significant effect on students' performance. Against these contradictory findings, it is also imperative to investigate whether school location has an effect on students' practical skills acquisition in qualitative analysis and any effect of the teachers' procedural knowledge on the school location on qualitative analysis. This study therefore, determined the effect of procedural knowledge instructional technique on chemistry students' practical skills acquisition and with respect to school location as a gap which this study intends to fill in the teaching of qualitative analysis.

## CONCLUSION

The study has shown that PKIT has significant effect on students' practical skills acquisition in qualitative analysis. The study showed that PKIT was more effective and efficacious than the conventional demonstration strategy (CDS) in bringing about more students' practical skills acquisition in qualitative analysis. School location had statistically significant effect on students' practical skills acquisition in qualitative analysis. In practical skills acquisition, urban students scored higher than rural students did. There was a significant interaction effect of instructional techniques and school location on students' mean practical

skills acquisition scores in qualitative analysis. The outcome of this study has a number of educational implications for students, teachers, teacher-training institutions and the ministries of education. These implications are discussed as follows. The study shows that PKIT raised students' practical skills acquisition in qualitative analysis. PSAQARS instrument provides a guide for teachers to be able to construct their own educational instrument and for the validation, quality evaluation and grading of

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