



Assessment of Level of Science Process Skills Possessed by Senior Secondary School Chemistry Students

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Abstract

The study assessed the level of science process skills possessed by secondary school chemistry students. Two research questions and one null hypothesis guided the study. A descriptive survey design was adopted. The population of the study is 5,023 SS2 chemistry students, with a sample size of 252. The data was collected through observational technique. A rating scale and practical test were instruments used. The two instruments were face validated by three experts in Department of Science Education, University of Nigeria, Nsukka. Cronbach alpha technique and Kendall coefficient of concordance were used to test the reliability of the instruments with index of 0.71 and 0.82. Mean, standard deviation and ANOVA were used for analysis. Result showed that chemistry students possessed a poor level of quantitative science process skills. Therefore, it was recommended that, there should be a continual use of the laboratory, to help develop science process skills of chemistry students.

Keywords: Science, Science process skills, Chemistry, School location

Introduction

The knowledge of science in the advancement of a nation cannot be overemphasized; This is because science forms the bedrock for all technological growth. The acquisition of scientific knowledge is very important in the development and production of innovative technologies that enhance healthy and conducive life style. Science is a process that adopts hypothetic deductive approach, which involves the use of a number of skills such as questioning, classifying, hypothesizing, experimenting, predicting, making operational definitions, inferring, manipulating instruments and variables, communicating, formulating models, interpreting data and observing (Mbajiorgu, 2014). Science is a process of inquiry into the unknown to gain better understanding of nature, events and phenomena through a well-defined procedure leading to the development of creative reasoning ability and problem-solving skills in an individual to positively impact the environment. Bradford (2017) viewed science as a systematic and logical approach of discovering how things in the universe work and as a body of knowledge accumulated through the discoveries about the things in the universe. Discovering the knowledge of how things work in the universe requires the understanding of nature of science.

The nature of science is dichotomous, in that, it is both a body of knowledge and a process of acquiring new knowledge. In other words, science is categorized into 'process' and 'product' (Sadhana,

2017 and Nwosu & Ibe, 2014). The 'process' of science is categorized into two, namely; scientific attitude and science process skills; while the 'product' of science are facts, concepts, principles, theories and laws. Scientific attitude is the ability to react consistently, rationally and objectively in certain ways to a novel or problematic situation (Olasehinde & Olatoye, 2014). Scientific attitude can also be the mindset to do things in a way that rely on proven and empirical principles rather than unverified principles. Scientific attitude is not adequate enough to produce a more reliable outcome, without the use of science process skills (SPS).

Science process skills are hands-on and minds-on skills that are deployed in solving scientific problem. Science process skills provides framework on how scientists think, work and study problem as well as seeking for solution in a scientific manner (Idiege, Nja & Ugwu, 2017). According to Safaah, Muslim, and Liliawati (2017) science process skills are set of skills used in conducting scientific activities and using scientific information in solving problem. Science process skills originated from a program named 'Science- A Process Approach' (SAPA) introduced by 'American Association for Advancement of Science' (AAAS) in the year 1967. The AAAS classified SPS into the basic and integrated skills which were fifteen (15); the basic science process skills are eight (8), while integrated science process skills are seven (7). The basic science process skills are fundamental skills that are necessary for scientific discovery. Examples of basic



science process skills are; observing, measuring, classifying, communicating, predicting, inferring, using numbers and questioning. Integrated science process skills are higher skills that are the pillars, which are built on the existence of basic science process skills. Examples of integrated science process skills are; formulating hypotheses, experimenting, manipulating and controlling variables, interpreting data, defining operationally, formulating models and presenting information. The basic science process skills that were assessed in this study are; observing, measuring, classifying, communicating, inferring, and recording/using numbers; while the integrated science process skills that were assessed in this study are; formulating hypotheses, designing experiment, and manipulating variables. These science process skills were assessed because it is captured in senior secondary school two (SS2) syllabus. Both basic and integrated science process skills are deployed through practical experiences in science subjects which chemistry is one of such subjects.

The importance of chemistry cannot be overemphasized, most of the activities carried out daily can be explained in the context of chemistry, such as 'cooking, bleaching of cloth, purification of water, separation techniques, biochemical changes in the body and these activities are indispensable in our everyday life. Chemistry is a practical science subject that provides students with the opportunity to acquire and use science process skills to solve problems in their daily activities and contribute to the development of the nation (Abungu, Okere & Wachanga, 2014). Chemistry is categorized into five (5) main branches, namely; physical chemistry, inorganic chemistry, analytical chemistry, organic chemistry and biochemistry. This study focused particularly on analytical chemistry, because practical chemistry in secondary schools is centred on analytical chemistry. Analytical chemistry is an aspect of chemistry that deals with the study of the chemistry of matter and the development of tools to measure properties of matter. According to Wafaa and Yassmen (2019) Analytical chemistry is divided into two (2), the qualitative and quantitative chemical analysis.

Firstly, quantitative chemical analysis is a branch of analytical chemistry that deals with the process of determining the amount of an analyte in a mixture. Quantitative chemical analysis is further divided into three (3), namely; gravimetric analysis, volumetric analysis and instrumental analysis. The

area that is mostly taught in secondary schools is volumetric analysis, therefore, this study laid emphasis on volumetric analysis. Volumetric analysis also known as titrimetric analysis is a method in quantitative chemical analysis in which the amount of a substance is determined by the measurement of the volume that substances occupy (Wafaa & Yassmen, 2019). Secondly, qualitative chemical analysis is the branch of analytical chemistry, which involves identification of species in a mixture. According to Clauder (2021) in qualitative analysis procedure, the chemical properties of an unknown substance are determined by systematically reacting the unknown reagent with a number of different reagents, in order for the unknown to be identified. Qualitative and quantitative chemical analysis are the litmus test that determine the extent to which students possess adequate science process skills in chemistry; because science process skills are needed in answering questions in both qualitative and quantitative chemical analysis sections in chemistry. Therefore, the level of science process skills possessed by senior secondary school chemistry students determines their achievements in chemistry practical examination. The importance of science process skills cannot be overemphasized, as it is the center of science learning. According to Safaah, Muslim and Liliawati (2017) it is important in the conceptual understanding of science and in everyday life.

Over the years, it has been observed that there has been poor achievement of students in chemistry. This is in line with the WAEC Chief examiner's report (2016-2019) that students exhibited poor qualitative analysis skills, inability to deduce inference from observation, poor mathematical skill, wrong use and omission of units (WAEC, 2016), inability to define concepts, poor communication skill (WAEC, 2017). These inconsistencies also play out among chemistry students in Awka Education Zone, as students' achievement though relatively good but still inconsistent over the years (2018, 2019 and 2020) (Post Primary Schools Service Commission, (PPSSC) Awka Education Zone). These inconsistencies in the achievement of chemistry students worries the researcher if chemistry students do not possess adequate science process skills necessary for solving chemistry practical questions. In spite of the important role science process skills plays in learning chemistry and in equipping students to be able to solve critical problems, the achievement of chemistry students has remained consistently poor.



Oginni, Awobodu, Alaka, and Saibu (2013) also pointed out some factors that could be responsible for influencing students' level of science process skills, among which is school location. This implies that students are influenced either positively or negatively based on the environment in which they study.

School location is the nature of the community in which a school is situated; it's either situated in urban, semi-urban or rural area. School location according to Okorie and Ezeh (2016) is a particular place, in relation to other areas in the physical environment (rural or urban), where the school is sited. Urban schools are densely populated with more social amenities like good roads, social centers, equipped laboratories and internet facilities. Semi-urban schools are schools that do not wholly have the characteristics of urban areas. Semi-urban is a fast growing rural into urban, but cannot be called either a city or a village. According to Steven and Hubert (2008) semi-urban is a rural population living within the hinterlands of large cities, spontaneously transforming their rural lifestyles into urban without leaving their rural environments. Rural schools are those located at the remote area where population is less and most social amenities are lacking but harbors many local and natural habitats. School location can be a determinant that influences the extent to which students possess science process skills. Some literatures indicated that school location has no significant impact on the possession of science process skills of chemistry students (Ezeudu & Obi, 2013; Igwebuike & Osabuohien, 2013; & Omajuwa, 2011). This notwithstanding, other studies indicated that school location has significant impact in the possession of science process skills (Awodun & Oyeniyi, 2018; Okorie & Ezeh, 2016; & Agbaje & Awodun, 2014). The inconsistencies of findings on school location as an influence on science process skills spur the researcher to look into the influence of school location on the level of science process skills possessed by chemistry students. From all the empirical literatures reviewed, it was shown that several studies that carried out research on science process skill dealt either with qualitative or quantitative chemical analysis; none of the studies assessed skills both in qualitative and quantitative chemical analysis. Therefore, this study assessed the science process skills of chemistry students both in qualitative and quantitative chemical analysis in Awka Education Zone.

In the light of this, the purpose of the study is to assess the level of science process skills possessed by chemistry students in secondary schools. The specific purpose of the study is to assess the:

1. level of science process skills possessed by chemistry students in secondary school.
2. influence of school location on the level of science process skills possessed by chemistry students in secondary schools.

Based on the purpose, the following research questions guided the study:

1. What is the level of science process skills possessed by chemistry students in secondary schools?
2. What is the influence of school location on the level of science process skills possessed by chemistry students in secondary schools?

In line with the purpose a null hypothesis guided the study and was tested at 0.05 alpha level

HO₁: School location has no significant influence on level of science process skills possessed by secondary school chemistry students.

Methods

The study adopted descriptive survey design. Descriptive survey design is a research design aimed at collecting data about a population, and describing the characteristics, features or facts of that given population in a systematic manner (Nworgu, 2018). The total population of SS2 chemistry students in Awka Education Zone is 5,023 from (61) public secondary schools. 252 SS2 chemistry students were sampled using simple random sampling and purposive sampling techniques. The first sampling technique was used to draw two (2) local Government areas out of five (5). The second technique was used to select three (3) schools each from the two L.G.A. Purposive sampling was used because only schools with functional laboratory were needed. Two instruments were used for the study, the first is a rating scale titled "Qualitative and Quantitative Analysis Rating Scale (QQARS)". The instrument (QQARS) consists of two (2) sections; section A and section B. 'Section A' elicited the basic information of the students while 'Section B' contained 32 items for qualitative chemical analysis and 27 items for quantitative chemical analysis, which helped to indicate the nine (9) science process skills for the study. Section B of the instrument was calibrated in positive 4-points Likert scale: Poor (P) – 1 point, Fair



(F) – 2 points, Good (G) – 3 points, and Excellent (E) – 4 points. QQRAS was adapted from Ugwu (2014); some changes were made in it, in order to be suitable for the study. First, the items for “interpreting and predictive skills” were removed because these skills were not part of the study, rather items under ‘formulating hypotheses’ was added in the qualitative chemical analysis section because it was part of the study. In addition, twenty-seven items were formulated for the quantitative chemical analysis section. The second instrument is ‘Chemistry Practical Achievement Test (CPAT)’, which was adopted from “West African Senior School Certificate Examination” (WASSCE), for the year 2018.

The instruments were validated by three experts from Department of Science Education, University of Nigeria, Nsukka. The instruments were trial tested on twenty (20) senior secondary (SS2) chemistry students in a school that has similar characteristics with the area of study. The students

were observed and rated by four (4) chemistry teachers using the rating scale. The reliability of the rating scale and chemistry practical test were determined using Cronbach alpha and Inter-scorer reliability technique and reliability coefficients of 0.71 and 0.82 were obtained, which indicates the instruments were reliable. Mean and standard deviation were used to answer research questions while hypothesis was tested using One-way Analysis of Variance (ANOVA) at 0.05 level of significance, because the variable (school location) tested has three levels. When the mean is 2.50 or greater than 2.50, it indicates that chemistry students do possess adequate level of science process skills, but when the mean is less than 2.50, it indicates that, chemistry students do not possess adequate level of science process skills.

Results

The data were analysed with respect to research questions and hypothesis.

Table 1: Mean (\bar{x}) and standard deviation (SD) of qualitative and quantitative science process skills

S/N	Science Process Skills	No. of Items	No. of students	Mean	Std. Deviation	Level
Qualitative Analysis						
1	Observational Skill	8	252	2.77	0.45	High
2	Classification Skill	3	252	2.75	0.58	High
3	Recording/Reporting Skill	4	252	3.85	0.62	High
4	Measuring Skill	2	252	2.73	0.61	High
5	Manipulating/Controlling Variables	3	252	2.92	0.58	High
6	Designing Experiment	4	252	2.63	0.56	High
7	Communication Skill	3	252	2.66	0.46	High
8	Inferring Skill	3	252	2.66	0.48	High
9	Formulating Hypotheses	2	252	2.58	0.67	High
Overall Mean and SD			252	2.84	0.56	High
Quantitative Analysis						
1	Observational Skill	2	252	2.18	0.37	Low
2	Designing Experiment	7	252	2.64	0.49	High
3	Manipulating/Controlling Variables	7	252	2.54	0.47	High
4	Measuring Skill	3	252	2.53	0.50	High
5	Recording/Reporting Skills	3	252	2.62	0.53	High
6	Communication Skill	2	252	2.41	0.60	Low
7	Inferring Skill	1	252	2.31	0.84	Low
8	Classifying Skill	1	252	2.49	0.90	Low
9	Formulating Hypotheses	1	252	2.41	0.91	Low
Overall Mean and SD			252	2.45	0.62	Low

Table 1 showed the level of science process skills possessed by chemistry students in both qualitative and quantitative science process skills. All the skills for qualitative chemical analysis fell within the mean range of 2.50-4.00, which showed that chemistry students all possessed a high level of science process skills in qualitative chemical analysis. Meanwhile,

skill 1, 6, 7, 8, and 9 of quantitative chemical analysis fell within the mean range of 2.18-2.49, which showed that chemistry students possessed a fair/poor level of science process skills in quantitative chemical analysis, especially in the areas of observing, communicating, inferring, classifying, and formulating hypotheses.

Table 2: Mean (\bar{x}) and (SD) of qualitative and quantitative analysis skills of urban, semi-urban and rural students

S/ N	Science Process Skills	No. of Urban students = 146			No. of Semi-Urban = 52			No. of Rural students = 54			
		No. of Items	$\bar{x}(u)$	SD(u)	Level	$\bar{x}(s)$	SD(s)	Level	$\bar{x}(r)$	SDr	Level
Qualitative Analysis Skills											
1	Observational	8	2.84	0.41	High	2.38	0.45	Low	2.96	0.32	High
2	Classification	3	2.83	0.58	High	2.40	0.60	Low	2.89	0.39	High
3	Recording/Reporting	4	3.90	0.63	High	3.51	0.54	High	3.74	0.51	High
4	Measuring	2	2.83	0.54	High	2.32	0.61	Low	2.82	0.61	High
5	Manipulating/Controlling Variables	3	3.07	0.54	High	2.54	0.62	High	2.88	0.49	High
6	Designing Experiment	4	2.67	0.49	High	2.22	0.62	Low	2.92	0.41	High
7	Communication	3	2.69	0.46	High	2.48	0.44	Low	2.77	0.44	High
8	Inferring	3	2.70	0.47	High	2.41	0.52	Low	2.80	0.41	High
9	Formulating Hypotheses	2	2.59	0.63	High	2.37	0.82	Low	2.74	0.58	High
Overall Mean and SD			2.90	0.52	High	2.51	0.58	High	2.94	0.46	High
Quantitative Analysis Skills											
1	Observational	2	2.24	0.36	Low	1.98	0.31	Low	2.19	0.36	Low
2	Designing Experiment	7	2.75	0.54	High	2.40	0.39	Low	2.57	0.32	High
3	Manipulating/Controlling Variables	7	2.54	0.50	High	2.34	0.38	Low	2.73	0.38	High
4	Measuring	3	2.68	0.49	High	2.23	0.43	Low	2.45	0.48	Low
5	Recording/Reporting	3	2.65	0.55	High	2.37	0.50	Low	2.75	0.44	High
6	Communication	2	2.45	0.59	Low	2.10	0.60	Low	2.58	0.54	High
7	Inference	1	2.19	0.85	Low	2.05	0.69	Low	2.87	0.70	High
8	Classification	1	2.55	0.90	High	1.98	0.80	Low	2.81	0.80	High
9	Formulating Hypotheses	1	2.57	0.86	High	1.69	0.87	Low	2.68	0.74	High
Overall Mean and SD			2.51	0.63	High	2.12	0.55	Low	2.62	0.52	High

Table 2 showed that the average mean of level of science process skills in qualitative analysis is in the range of 2.51-2.94, which indicates that urban, semi-urban and rural chemistry students all have a high level of science process skills in qualitative chemical analysis. But, semi-urban students had a poor level of science process skills in the areas of observation, classifying, measuring, designing experiment,

communicating, inferring and formulating hypotheses in qualitative chemical analysis. However, semi-urban students had a overall poor level of science process skills in quantitative chemical analysis ($\bar{X}=2.12$; $\sigma=0.55$). Also, urban chemistry students has a poor level of science process skills in quantitative chemical analysis, especially in the area of observing, communicating and inference ($\bar{X} = 2.24, 2.45, 2.19$;



$\sigma = 0.36, 0.59, 0.85$). Likewise, rural chemistry students had a poor level in the areas of observing

and measuring in quantitative chemical analysis ($\bar{X} = 2.19, 2.45; \sigma = 0.36, 0.48$).

Table 3: ANOVA table showing the mean difference among urban, semi-urban and rural schools in qualitative and quantitative chemical analysis skills

	SS	Df	MS	F	Sig	Inference
Qualitative Skills						
Between Groups	7.013	2	3.507	50.93	0.00	Significant
Within Groups	17.143	249	0.069			
Total	24.156	251				
Quantitative Skills						
Between Groups	7.667	2	3.833	47.58	0.00	Significant
Within Groups	20.060	249	0.081			
Total	27.727	251				

Table 3 showed that there is a statistical significant difference among urban, semi-urban and rural chemistry students in their level of science process skills both in qualitative and quantitative chemical analysis ($F_{(2,249)} = 50.93 \text{ \& } 47.58, p < 0.05$). In order to check where the difference lies among chemistry students based on their level of science process skills, Tukey HSD was conducted. The result of the post hoc test showed that there was no difference between the level of science process skills of urban and rural chemistry students in qualitative chemical analysis. However, there is a statistically significant difference in the level of science process skills between urban and semi-urban; and semi-urban and rural students in qualitative chemical analysis. Also, there is a statistically significant difference in the level of science process skills between urban and rural; urban and semi-urban; and rural and semi-urban students in quantitative chemical analysis.

Discussion

The study revealed that chemistry students have a high level of science process skills in qualitative chemical analysis, but a poor level of science process skills in quantitative chemical analysis, especially in the areas of observing, communicating, inferring, classifying, and formulating hypotheses. This could be that the qualitative chemical analysis requires less tasking procedure unlike the quantitative chemical analysis that require more complex processes in arriving at a given measurement. The result further showed that school location had a great influence on the level of science process skills possessed by chemistry students. Rural chemistry students had a high level of science process skills than the urban students. Likewise urban chemistry students had a

high level of science process skills than the semi-urban chemistry students in both qualitative and quantitative chemical analysis. The researcher believed that the result was so because of unequal distribution of equipments, reagents and facilities among different location. Another reason may be as a result of students’ interest and attitude towards chemistry. The finding disagreed with Akinwumi (2017), Aydogdu (2017) and Ongowo (2017) who in their studies found that urban students had high mastery of science process skills than rural students, but agreed with Apuh (2020) who stated that some of the reasons for chemistry students academic achievements is due to resource availability, students attitude and students regularity to class. Also, Irwanto, Rohaeti, and Prodjosantoso (2018) stated that chemistry students who have high science process skills tend to have positive attitude towards chemistry.

Conclusion

Based on the results of the study, it was revealed that chemistry students have poor level of science process skills in quantitative chemical analysis, especially in the areas of observing, communicating, inferring, classifying, and formulating hypotheses. Also, school location had a great influence on the level of science process skills possessed by chemistry students.

Recommendations

Based on the findings, the following recommendations were made:

1. Standard laboratories and laboratory apparatus should be erected and provided for schools irrespective of the school location.



2. Special care and attention should be given to the maintenance, management and security of chemistry laboratory and the apparatus. This will ensure continual use of the laboratory and students will adequately develop more interest for chemistry practical; and in the process develop their science process skills in both qualitative and quantitative chemical analysis.

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