

Level of Acquisition of Basic and Integrated Science Process Skills by Secondary School Chemistry Students in Qualitative Analysis in Abakaliki Education Zone of Ebony State, Nigeria

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Abstract

The study focused on ascertaining the level of acquisition of basic and integrated science process skills by secondary school Chemistry students in qualitative analysis in Abakaliki Education Zone. Six (6) research questions and four (4) hypotheses guided the study. Descriptive survey design was used. The population of the study comprised of two thousand, eight hundred and seventy two (2872) Senior Secondary III Chemistry students. Multi-stage sampling technique was used to select a sample two hundred and seventy five (275) students. The instruments of data collection were the Science Process Skill Observation Schedule and the Qualitative Analysis Practice Test. The instruments were validated by three experts in the Science Education Department, Ebony State University, and Abakaliki. The internal consistency of the instruments was determined using Cranach Alpha with a score of 0.87 while Kendall Coefficient of concordance was used to test for the scorer reliability giving a score of 0.77. Mean, standard deviation, t-test and ANOVA were used for data analysis. Results show that the Chemistry students acquired high levels of the basic science process skills of observation, classification, measurement, communication and prediction; as well as high levels of the integrated science process skills of controlling variables, manipulation, inferring and interpretation of data but a low level of the skill of experimenting. There was no significant difference in the level of acquisition of basic process skills based on gender and school location. There was no significant difference in the level of acquisition of integrated process skills based on gender but there was a significant difference based on school location. Therefore, the researchers recommended among others that Chemistry laboratories in every public school in the state should be properly equipped irrespective of school location.

Keywords: Qualitative Analysis, Chemistry, Skills acquisition, Basic, Integrated

Introduction

Science serves as the foundation of knowledge through which humanity understands the natural environment and harnesses the resources found therein for the benefit of the society. The developments in science are a testament to the ingenuity, curiosity, adventure and resilience of man. According to Tijuana and Adeduyigbe (2025), science plays a crucial role in building a foundation for technological advancement, economic transformation and social progress. Belk, Scandal, Nair, Zhang, Georamas and Elmore (2025) define science as the use of evidence to construct testable explanations and predictions of natural phenomenon as well as the knowledge generated. Science reaches out to new ideas and facts which contribute to the ever-growing stack of knowledge and provides children with the opportunities to grow their innate curiosity and discovery about the natural world (Mullein, Tamaris and Supriyah, 2019). According to Nikola, Aruba and Habinchuli (2022), science is learnt as a process and a product although these two are not always accorded equal attention to the learning process. Therefore, Kamiah and Adamou (2022) assert that science teaching, especially the learning of Chemistry should be an active and constructive process which enables knowledge construction required for an active participation on the part of the learners.

Chemistry is a fundamental science subject which is included in the science curriculum of the secondary schools in Nigeria. Chemistry is defined as the branch of science that deals with the study of the composition and properties of matter, changes in matter and the laws and principles that govern these changes (Tegegne and Kalka, 2023). According to Szydlo (2022), the first chemists were craftsmen: they used chemical changes for practical goals and these were achieved through their chief attributes which were common sense, intuition and manipulative skills. Ugwuanyi and Wafer (2021) opine that Chemistry cannot be isolated from our lives since human beings have always been in contact with chemical substances and technological products such as cosmetics, drugs, detergents, soaps, fertilizers among others.

Chemistry is generally referred to as the mother of all sciences because the choice of courses and careers in science and applied science is determined by how well a student performs in Chemistry at the Senior Secondary Certificate Examination (SSCE) (Fee and Ababa, 2023). Therefore, Chemistry is a prerequisite subject for offering most science-oriented courses in the tertiary institutions (Eke and Denney, 2022). Chemistry is a practical subject structured around four (4) themes: the chemical world; chemistry and the environment; chemistry and industry; chemistry and life (Paha, Gbadamosi and Boniface, 2017). These four themes depict that the study of Chemistry requires students to acquire adequate science process skills.

Science process skills are defined as hands-on and mind-on skills that are deployed in solving scientific problems (Diego, Najd and UGu, 2017). It provides a framework of how scientists think, work and study problems as well as seeking solution in a scientific manner. According to Valued and Patel (2022), science process skills originated from a program named “Science A Process Approach” (SAPA) introduced by the American Association for the Advancement of Science (AAAS) in the year 1967. The AAAS classified science process skills into basic and integrated processes which are fifteen in total. The basic science process skills are eight in number (observation, communication, classification, measurement, inference, prediction, counting numbers and questioning) while the integrated science process skills include (controlling variables, manipulation, experimenting, defining operationally, interpretation of data, formulating hypotheses and formulating models) (Adowa and Anglo, 2015).

Diego, Najd and UGu (2017) note that the basic science process skills are the foundational skills and are used for the development of the more complex integrated science process skills. The integrated science process skills are difficult and more appropriate for the senior secondary and tertiary school levels for the formation of models, experimenting and inferring (Ugwuanyi and Wafer, 2021). According to Chellamani and Anjugam (2024), science process skills can be acquired by laboratory experiments where the students learn problem-solving skills, understanding the concepts of science, handling some of the common measuring instruments, equipment and chemicals, setting up simple apparatus, making observations, collecting data and presenting it in an appropriate format, interpreting and drawing conclusions and preparation of report.

In the Nigerian senior secondary school Chemistry curriculum, chemistry practical lessons are limited to the branch of Chemistry known as analytical chemistry in which the students are expected to actively engage in laboratory practices in qualitative analysis and quantitative analysis and by so doing develop the necessary science process skills. According to Alcan (2021), qualitative analysis determines which chemicals a sample contains whereas quantitative analysis allows determining which (how much) of these chemicals are numerically present in a sample. Silvia, Olio, Bastion, Bastion and Demonic (2024) states that qualitative analysis is the part of analytical chemistry that aims to ascertain the presence of an element or compound in a given sample. A constant and sustained exposure to Chemistry practical lessons ensures that secondary school students acquire both basic and integrated science process skills. Unfortunately, students are rarely exposed to practical work because Chemistry teachers do not place much value on laboratory activities as they believe that it takes away time from teaching the contents of the examination-driven curriculum (Fee and Ababa, 2023). Also, Ana so (2020) reports that a lack of chemistry practical by Chemistry students results in poor communication as well as observation skills. The acquisition of science process skills can be affected by student factors and school factors. For the purpose of this study, these factors can be composed under gender and school location. Kenny (2020) opines that the academic success of students can be affected by the type of school that they attend.

The progress for change in the gender-based disparities in occupational and academic choices that requires science process skills suggest that gender segregation in the education and labor market remains persistent. Orji, Koneke, Ilk, Nous and Chidiebube (2026) opine that in the Chemistry classrooms in Nigerian secondary schools, gender-stereotyping has resulted in the low participation of girls in Chemistry. Gender is defined as a cluster of characteristics that differentiates males from females (Aziz, Anglo and Agro, 2022). More often than not, the poor participation of girls in Chemistry can be attributed to the social dynamics of the home as boys are given freedom for studies in Chemistry while the girl child has less time at hand for a revision of class work and studying leading to a loss of interest and poor attitude (Idea, 2017). Interestingly, Muhammad and Farkhunda (2020) report a vivid discrimination between girls and boys in the teaching and learning of Chemistry. However, Jack and Japheth (2020) assert that gender does not affect students' academic achievement in Chemistry when the male and female students are taught under the same conditions (Jack and Japheth, 2020).

The location of a school plays a fundamental role in the students' access to quality Chemistry education because Chemistry is a practical-oriented science. The lack of learning aids, absence

of well-equipped chemistry laboratories, non-availability of competent and well-qualified Chemistry teachers and the use of teacher-centered methods of instructions are inimical to the acquisition of science process skills in Chemistry. This is very common in rural secondary schools; therefore Bozeman, Mattagami and Moesia (2022) assert that the location of a school plays a major role in the students' achievement in science. Okonkwo, Oyo and Agro (2022) define school location as the place where a school is sited, either in the rural or urban area. Jagged and Keya (2022) identifies rural areas as those categories of communities with low population, poor or no social amenities, poor school environment including problems with teacher-student ratio, poor school location, poor classroom ventilation, poor lighting in classrooms. On the other hand, urban areas have moderate population, electricity, water supply, better learning facilities and more teachers (Obi, Agade and Urge, 2025). However, curriculum designers and examination bodies do not make allowances for differences in gender and school location, hence students, irrespective of their gender and school location are subjected to the same teaching curriculum, teaching methods and examinations (Allah nana, Akanke, Vintner, Alake and Alake, 2018).

Statement of problem

The acquisition of science process skills is fundamental to the proper understanding of Chemistry and it is imperative that the skills are developed by the students through constant exposure to laboratory practical lessons. Unfortunately, this is not the case as Myola and Ezek (2024) report that in most secondary schools, Chemistry is taught as a bundle of abstractions without practical experiences. This has resulted to students' low acquisition of science process skills which has become more evident in Chemistry students' performance in public examinations (Jack, 2018). In the Senior Secondary School Certificate Examinations (SSCE) organized by the National Examination Council (NECO) and the West African Examination Council (WAEC) for the senior secondary school three (SSS3) students, all the questions asked in practical Chemistry Paper 3 are to test the Chemistry students' knowledge in practical skills and require that they demonstrate one form of science process skill or the other. The WAEC Chief Examiner's Report (2019) indicates that Chemistry students exhibited poor qualitative analysis skills, inability to deduce inference from observations, inability to define concepts and poor communication skills. This research therefore intends to determine the level of acquisition of basic and integrated science process skills by secondary school Chemistry students in qualitative analysis in the Abakaliki Education Zone of Ebony State and how this can be affected by gender and school location.

Purpose of Study: The main purpose of the study was to determine the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis. Specifically, the study seeks to:

1. Ascertain the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis.
- 2 Determine the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis.
3. Ascertain the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis in terms of gender.

4. Ascertain the level of acquisition of basic science process skills by secondary school Chemistry students in terms of school location.
5. Find out the level of acquisition of integrated science process skills by secondary school Chemistry students in terms of gender.
6. Determine the level of acquisition of integrated science process skills by secondary school Chemistry students in terms of school location.

Research Questions

1. What is the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis?
2. What is the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis?
3. What is the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis based on gender?
4. What is the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis based on school location?
5. What is the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis based on gender?
6. What is the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis based on school location?

Hypotheses

The following hypotheses were tested at 0.05 level of significance

- HO₁:** There is no significant difference in the level of acquisition of basic science process skills of male and female secondary school Chemistry students in qualitative analysis.
- HO₂:** There is no significant difference in the level of acquisition of basic science process skills in qualitative analysis between secondary school Chemistry students in urban and rural schools.
- HO₃:** There is no significant difference in the level of acquisition of integrated science process skills of male and female secondary school Chemistry students in qualitative analysis.
- HO₄:** There is no significant difference in the level of acquisition of integrated science process skills in qualitative analysis between secondary school Chemistry students in urban and rural schools.

Methodology

The study adopted a descriptive survey design. The area of study was Abakaliki Education Zone of Ebony state. Six research questions and four hypotheses guided the study. The population of the study was two thousand, eight hundred and seventy two (2872) Senior Secondary three (SS3) Chemistry students from the seventy seven (77) public secondary schools in the Abakaliki education zone in the 2025/2026 academic session. A sample of two hundred and seventy five (275) SS3 Chemistry students from eight (8) secondary schools was drawn from

the population. Multi-stage sampling technique was used to obtain a sample of two hundred and seventy five (275). First, purposive sampling was used to select the eight schools. Purposive sampling was used because only schools with functional Chemistry laboratories were required for the study. Secondly, proportionate stratified random sampling techniques were used in composing the number of schools based on gender and school type; the choice of this technique was to ensure a balance in the attributes expected. All the SS3 Chemistry students in each of the sampled schools were used for the study. Two instruments were used for the study:

1. Science Process Skill Rating Scale (SPSRS)
2. Qualitative Analysis Practice Test (QAPT)

The SPSRS was adapted from Ugwu (2014). The instrument consists of fifteen (15) qualitative analysis items based on activities that indicate five (5) integrated science process skills on which the students would be assessed. The raters/research assistants rated the students using scale points of Very Great Extent-4 points; Great Extent-3 points; Low Extent-2 points; Very Low Extent-1 point. The instrument which was already validated was confirmatory validated by three experts, one in Measurement and Evaluation and two in Chemistry Education from the Science Education Department of Ebony State University, Abakaliki. The instrument was trial tested on ten (10) students chosen from a different secondary school in the Afikpo Education Zone of Ebony state. The students were observed and rated by three Chemistry teachers who had been duly briefed on how to make use of the rating guide and their scores were collated. Kendall's Coefficient of Concordance (W) was used to establish the scorer reliability of the instrument and a coefficient of 0.77 was obtained. For the internal consistency of the instrument, Cranach Alpha estimate was used and it yielded a reliability coefficient of 0.87. Hence, the instrument is reliable. The data collected was analyzed using mean, standard deviation, t-test and ANOVA. A mean score of greater than 3.1 or less than or equal to 4.0 ($3.1 < x \leq 4.0$) on a skill is regarded as Very Great Extent; a mean score of greater than 2.1 but less than or equal to 3.1 ($2.1 < x \leq 3.1$) on a skill is regarded as Great Extent; a mean score of greater than 1.1 but less than or equal to 2.1 ($1.1 < x \leq 2.1$) on a skill is regarded as Low Extent and a mean score of greater than 0.1 but less than or equal to 1.1 ($0.1 < x \leq 1.1$) on a skill is regarded as very low extent.

Results:

Research Question 1: What is the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis?

Table 1: Summary of descriptive statistics (mean and standard) deviation on the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis

S/n	Level of Basic Science Process Skill	N	$\bar{x}$	SD	Remark	Level
	Observation Skills					
1	Recognizing the color of the precipitate formed during chemical reactions	275	3.12	1.13	VGE	High
2	Recognizing the effect of gas evolved upon	275	3.03	1.1	VGE	High

	heating mixture on the color of litmus paper			6		
3	Detecting effervescence of gas when a solution is added to the residue	275	3.08	1.2 4	VGE	High
	Cluster Mean		3.08	1.1 8	VGE	High
	Classification Skills					
4	Separating mixtures by filtering process	275	3.69	0.6 5	VGE	High
5	Grouping gasses according to their odor	275	2.88	1.1 9	GE	High
6	Writing down inference based on the observation	275	3.02	1.1 5	GE	High
	Cluster Mean		3.20	0.9 9	VGE	High
	Measurement Skills					
7	Estimating quantities of the required sample to be added	275	2.91	.86 3	GE	High
8	Estimating the quantity of drop of reagent to be added initially before excess	275	2.77	1.0 2	GE	High
9	Correctly adding exact recommended amount of distilled water (10ml) to the sample	275	2.75	1.2 9	GE	High
	Cluster Mean		2.81	1.0 6	GE	High
	Communication Skills					
10	Using correct technical terms in reporting results of experiment e.g. dissolves/soluble instead of melts	275	3.16	1.0 4	VGE	High
11	Describing briefly the observation made	275	3.07	1.1 7	VGE	High
12	Using the correct chemical symbol, formulae, ions in recording test carried out	275	2.98	1.2 1	GE	High
	Cluster Mean		3.07	1.1 4	GE	High
	Prediction Skills					
13	Suspecting correctly the ions in a sample of salt from the observation made before confirmatory	275	2.84	1.2 0	GE	High
14	Suspecting correctly the compound (s) in a sample of salt given from the physical state of the sample	275	2.75	1.3 4	GE	High
15	Suspecting correctly the nature of gas evolved	275	2.81	1.2 1	GE	High
	Cluster Mean		2.80	1.2 5	GE	High
	Overall mean		3.04	1.1	GE	High

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Results in Table 1 indicate that the Chemistry students had acquired to a high level the skills of observation, classification, measurement, communication and prediction with an overall mean and standard deviation of ($\bar{x}$ = 3.04, SD=1.17).

Research question 2: What is the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis?

Table 2: Summary of descriptive statistics (mean and standard deviation) on the level of integrated science process skills by secondary school Chemistry students in qualitative analysis.

S/N	Level of Integrated Science Process Skill	N	$\bar{x}$	SD	Remark	Level
	Controlling Variables Skills					
16	Washing test tubes properly	275	2.61	0.90	GE	High
17	Rinsing the test tubes with distilled water before use	275	2.37	1.13	GE	High
18	Shaking the test tube on addition of a reagent into a substance in test tube	275	3.54	0.85	VGE	High
	Cluster Mean		2.84	0.96	GE	High
	Experimenting Skills					
19	Setting up heating apparatus	275	2.07	0.97	GE	High
20	Holding test tube in a slanting position with test tube holder while heating	275	1.99	1.03	LE	Low
21	Heating substance in a conical flask	275	1.85	1.02	LE	Low
	Cluster Mean		1.97	1.01	LE	Low
	Manipulative Skills					
22	Properly folding the filter paper to fix it in the funnel	275	3.27	0.91	VGE	High
23	Using a glass rod to identify h=gas evolved on heating	275	2.84	1.04	GE	High
24	Handing test tube and droppers	275	2.85	0.94	GE	High
	Cluster Mean		2.99	0.96	GE	High
	Inference Skills					
25	Naming the gas evolved through its color, odor or actions on some compound	275	2.75	1.19	GE	High
26	Confirming the ions present in a sample of salt through its reaction with some reagents	275	2.77	1.24	GE	High
27	Inferring the nature of gas evolve in terms of acidic, alkaline or neutral through the action of litmus paper	275	2.75	1.18	GE	High
	Cluster Mean		2.76	1.06	GE	High
	Interpretation of Data Skill					

28	Making generalization based on observation	275	2.81	1.16	GE	High
29	Explaining correctly the observation made from reactions	275	2.82	1.21	GE	High
30	Explaining observation in clear and concise language.	275	2.82	1.19	GE	High
	Cluster Mean		2.82	1.19	GE	High
	Overall mean		2.67	1.08		High

Results in Table 2 show that the Chemistry students had acquired high levels of the skills of controlling variables, manipulation, inference and interpretation of data but a low level of the skill of experimenting with an overall mean and standard deviation of ($\bar{x}$ = 2.67, SD = 1.08)

Research Question 3: What is the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis based on gender?

Table 4.3: Summary of descriptive statistics (mean and standard deviation on the level of basic science process skills by secondary school Chemistry students in qualitative analysis based on gender.

S/ n	Items	Male			Level	Female			Level
		N	$\bar{x}$	SD		N	$\bar{x}$	SD	
	Observation Skills								
1	Recognizing the color of the precipitate formed during chemical reactions	140	3.23	1.09	High	135	3.01	1.16	High
2	Recognizing the effect of gas evolved upon heating mixture on the color of litmus paper	140	3.09	1.13	High	135	2.97	1.19	High
3	Detecting effervescence of gas when a solution is added to the residue	140	3.19	1.15	High	135	2.97	1.33	High
	Cluster Mean		3.17	1.12	High		2.98	1.23	High
	Classification Skills								
4	Separating mixtures by filtering process	140	3.67	0.68	High	135	3.70	0.61	High
5	Grouping gasses according to their odor	140	2.99	1.18	High	135	2.76	1.19	High
6	Writing down inference based on the observation	140	3.18	1.09	High	135	2.85	1.18	High
	Cluster Mean		3.28	0.99	High		3.10	0.99	High
	Measurement Skills								
7	Estimating quantities of the required sample to be added	140	3.05	0.71	High	135	2.77	0.93	High

8	Estimating the quantity of drop of reagent to be added initially before excess	140	2.90	0.98	High	135	2.64	1.04	High
9	Correctly adding exact recommended amount of distilled water (10ml) to the sample	140	2.81	1.25	High	135	2.69	1.33	High
	Cluster Mean		2.92	0.98	High		2.96	1.15	High
	Communication Skills								
10	Using correct technical terms in reporting results of experiment e.g. dissolves/soluble instead of melts	140	3.23	1.01	High	135	3.08	1.07	High
11	Describing briefly the observation made	140	3.18	1.23	High	135	2.96	1.11	High
12	Using the correct chemical symbol, formulae, ions in recording test carried out.	140	3.10	1.15	High	135	2.85	1.26	High
	Cluster Mean		3.17	1.13	High		2.96	1.15	High
	Prediction Skills								
13	Suspecting correctly the ions in a sample of salt from the observation made before confirmatory	140	2.91	1.13	High	135	2.77	1.27	High
14	Suspecting correctly the compound (s) in a sample of salt given from the physical state of the sample	140	2.84	1.20	High	135	2.65	1.26	High
15	Suspecting correctly the nature of gas evolved	140	2.97	1.19	High	135	2.84	1.22	High
	Cluster Mean		2.91	1.17	High		2.75	1.25	High
	Overall Mean		3.09	1.14	High		2.90	1.19	High

Results from Table 3 showed that male Chemistry students ($\bar{x} = 3.09$, SD=1.14) had acquired high levels of the basic process skills of observation, classification, measurement, communication and prediction while the female Chemistry students ($\bar{x} = 2.90$, SD=1.19) had acquired high levels of the basic science process skills of observation, classification, measurement, communication and prediction. The null hypothesis, H_{01} was used to test for the level of significant difference.

Research Question 4: What is the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis based on school location?

Table 4: Summary of descriptive statistics (mean and standard deviation) on the level of basic science process skills by secondary school Chemistry students in qualitative analysis based on school location.

S/ N	Items	Rural			Level	Urban			Level
		N	$\bar{x}$	SD		N	$\bar{x}$	SD	
	Observation Skills								
1	Recognizing the color of the precipitate formed during chemical reactions	127	3.07	1.24	High	148	3.17	1.03	High
2	Recognizing the effect of gas evolved upon heating mixture on the color of litmus paper	127	2.98	1.27	High	148	3.07	1.05	High
3	Detecting effervescence of gas when a solution is added to the residue	127	3.00	1.30	High	148	3.15	1.19	High
	Cluster mean		3.02	1.27	High		3.13	1.09	High
	Classification Skills								
4	Separating mixtures by filtering process	127	3.79	0.60	High	148	3.60	0.68	High
5	Grouping gasses according to their odor	127	2.87	1.26	High	148	2.89	1.13	High
6	Writing down inference based on the observation	127	3.04	1.22	High	148	3.00	1.08	High
	Cluster mean		3.23	1.03	High		3.16	0.96	High
	Measurement Skills								
7	Estimating quantities of the required sample to be added	127	2.90	0.80	High	148	2.93	0.92	High
8	Estimating the quantity of drop of reagent to be added initially before excess	127	2.65	0.98	High	148	2.89	1.03	High
9	Correctly adding exact recommended amount of distilled water (10ml) to the sample	127	2.48	1.30	High	148	2.98	1.24 2	High
	Cluster mean		2.68	1.03	High		2.93	1.06	High
	Communication Skills								
10	Using correct technical terms in reporting results of experiment e.g. dissolves/soluble instead of melts	127	3.13	1.09	High	148	3.18	0.99	High

11	Describing briefly the observation made	127	3.18	1.32	High	148	2.98	1.08	High
12	Using the correct chemical symbol, formulae, ions in recording test carried out	127	2.91	1.32	High	148	3.04	1.10	High
	Cluster mean		3.07	1.24	High		3.07	1.06	High
	Predication Skills								
13	Suspecting correctly the ions in a sample of salt from the observation made before confirmatory	127	2.84	1.27	High	148	2.84	1.14	High
14	Suspecting correctly the compound (s) in a sample of salt given from the physical state of the sample	127	2.82	1.32	High	148	2.68	1.17	High
15	Suspecting correctly the nature of gas evolved	127	2.87	1.30	High	148	2.76	1.14	High
	Cluster mean		2.84	1.29	High		2.76	1.15	High
	Overall Mean		2.97	1.24	High		3.01	1.14	High

Results from Table 4 indicate that there is not much disparity between the secondary school Chemistry students in the rural schools ($\bar{x} = 2.97, SD = 1.24$) when compared to students in the urban schools ($\bar{x} = 3.01, SD = 1.14$). The Chemistry students in the rural areas and the urban areas acquired high levels of the basic science process skills of observation, classification, measurement, communication and prediction. The null hypothesis, H_0 was used to test for the level of significance.

Research Question 5: What is the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis based on gender?

Table 5: Summary of descriptive statistics (mean and standard deviation) on the level of integrated science process skills by secondary school Chemistry students in qualitative analysis based on gender

S/ n	Items	Male				Female			
		N	$\bar{x}$	SD	Level	N	$\bar{x}$	SD	Level
	Controlling Variables Skills								
1	Washing test tubes properly	140	2.51	0.81	High	135	2.71	0.98	High

2	Rinsing the test tubes with distilled water before use	140	2.25	1.13	High	135	2.49	1.12	High
3	Shaking the test tube on addition of a reagent into a substance in test tube	140	3.75	0.69	High	135	3.33	0.95	High
	Cluster mean		2.83	0.88	High		2.84	1.03	High
	Experimenting Skills								
4	Setting up heating apparatus	140	1.89	0.91	Low	135	2.27	0.99	High
5	Holding test tube in a slanting position with test tube holder while heating	140	1.80	1.03	Low	135	2.19	1.00	High
6	Heating substance in a conical flask	140	1.59	0.93	Low	135	2.12	1.04	High
	Cluster mean		1.76	0.96	Low		2.19	1.01	High
	Manipulative Skills								
7	Properly folding the filter paper to fix it in the funnel	140	3.22	0.94	High	135	3.32	0.87	High
8	Using a glass rod to identify h=gas evolved on heating	140	2.85	1.08	High	135	2.82	0.99	High
9	Handing test tube and droppers	140	2.89	0.96	High	135	2.81	0.93	High
	Cluster mean		2.98	0.99	High		2.98	0.93	High
	Inference Skills								
10	Naming the gas evolved through its color, odor or actions on some compound	140	2.82	1.27	High	135	2.68	1.10	High
11	Confirming the ions present in a sample of salt through its reaction with some reagents	140	2.89	1.30	High	135	2.64	1.16	High
12	Inferring the nature of gas evolved in terms of acidic, alkaline or neutral through the action of litmus paper	140	2.93	1.21	High	135	2.57	1.13	High
	Cluster mean		2.88	1.26	High		2.63	1.13	High
	Interpretation of Data								
13	Making generalization based on observation	140	2.88	1.23	High	135	2.75	1.08	High
14	Explaining correctly the observation made from reactions	140	2.91	1.26	High	135	2.73	1.16	High
15	Explaining observation in clear and concise language.	140	2.89	1.36	High	135	2.75	1.11	High

	Cluster mean		2.89	1.28	High		2.74	1.12	High
	Overall Mean		2.67	1.18	High		2.68	1.11	High

Results from Table 5 show that the female Chemistry students have acquired high levels of the skills of controlling variables, experimenting, manipulation, inference and interpretation of data ($\bar{x}$ = 2.68, SD = 1.11). On the other hand, the male students had acquired high levels of the skills of controlling variables, manipulation, inference and interpretation of data and a low level of the skill of experimenting ($\bar{x}$ = 2.67, SD = 1.18). This was tested by the null hypothesis, H_0 to determine the level of significance.

Research Question 6: What is the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis based on school location?

Table 6: Summary of descriptive statistics (mean and standard deviation) on the level of integrated science process skills by secondary school Chemistry students in qualitative analysis based on school location

S/ n	Items	Rural			Level	Urban			Level
		N	$\bar{x}$	SD		N	$\bar{x}$	SD	
	Controlling Variables Skills								
1	Washing test tubes properly	127	2.19	0.83	High	148	2.97	0.80	High
2	Rinsing the test tubes with distilled water before use	127	1.87	1.03	Low	148	2.80	1.03	High
3	Shaking the test tube on addition of a reagent into a substance in test tube	127	3.60	0.88	High	148	3.49	0.82	High
	Cluster mean		2.55	0.91	High		3.09	0.88	High
	Experimenting Skills								
4	Setting up heating apparatus	127	1.72	0.84	Low	148	2.38	0.97	High
5	Holding test tube in a slanting position with test tube holder while heating	127	1.62	0.90	Low	148	2.30	1.03	High
6	Heating substance in a conical flask	127	1.46	0.75	Low	148	2.18	1.09	High
	Cluster mean		1.60	0.83	Low		2.29	1.03	High
	Manipulating Skills								
7	Properly folding the filter paper to fix it in the funnel	127	3.32	1.02	High	148	3.23	0.80	High
8	Using a glass rod to identify h=gas evolved on heating	127	2.68	1.25	High	148	2.97	0.79	High
9	Handling test tube and droppers	127	2.60	1.02	High	148	3.07	0.81	High
	Cluster mean		2.87	1.10	High		3.09	0.80	High
	Inference Skills								
10	Naming the gas evolved through its color, odor or actions on some	127	2.69	1.25	High	148	2.81	1.13	High

	compound								
11	Confirming the ions present in a sample of salt through its reaction with some reagents	127	2.65	1.29	High	148	2.87	1.19	High
12	Inferring the nature of gas evolve in terms of acidic, alkaline or neutral through the action of litmus paper	127	2.60	1.30	High	148	2.89	1.06	High
	Cluster mean		2.65	1.28	High		2.85	1.13	High
	Interpretation of Data								
13	Making generalization based on observation	127	2.65	1.28	High	148	2.96	1.04	High
14	Explaining correctly the observation made from reactions	127	2.60	1.33	High	148	3.01	1.06	High
15	Explaining observation in clear and concise language.	127	2.58	1.31	High	148	3.03	1.04	High
	Cluster mean		2.61	1.31	High		3.00	1.05	High
	Overall mean		2.46	1.19	High		2.86	1.01	High

Results from Table 6 indicate that secondary school Chemistry students from rural schools ($\bar{x}$ = 2.46, SD=1.19) had acquired high levels of the integrated science process skills of controlling variables, manipulation, inference and interpretation of data but a low level of the skill of experimenting. However, those from urban schools had high levels of all the integrated science process skills. This result was tested with the null hypothesis H_{04} to find out if the difference was significant.

H_{01} : There is no significant difference in the level of acquisition of basic science process skills of male and female secondary school Chemistry students in qualitative analysis

Table 7: Summary of t-test on the difference in mean rating on the level of acquisition of basic science process skills by male and female secondary Chemistry students in qualitative analysis.

Gender	N	$\bar{x}$	SD	Daft-cal	t-crib	Remark	
Male	140	3.09	1.14	273	1.35	1.97	NS
Female	135	2.90	1.19				

NS: Not Significant

The results from Table 7 shows that the t-calculated value of 1.35 is less than the t-critical value of 1.97, therefore the null hypothesis is accepted and the researchers conclude that there is no significant difference in the mean rating on the level of acquisition of basic science process skills by secondary school Chemistry students based on gender.

HO₂: There is no significant difference in the level of acquisition of basic science process skills in qualitative analysis between secondary school Chemistry students in urban and rural schools.

Table 8: Summary of t-test on the difference in mean rating on the level of acquisition of basic science process skills in qualitative analysis between secondary school Chemistry students in urban and rural schools.

School Location	N	$\bar{x}$	SD	Do	t-cal	t-crit	Remark
Urban	148	3.01	1.14	273	0.28	1.97	NS
Rural	127	2.97	1.24				

NS: Not Significant

Results from Table 8 showed that the t-calculated value of 0.28 is less than the t-critical value of 1.97 therefore the null hypothesis is accepted and the researchers conclude that there is no significant difference on the mean rating on the level of acquisition of basic science process skills by secondary school Chemistry students based on school location.

HO₃: There is no significant difference in the level of acquisition of integrated science process skills of male and female secondary school Chemistry students in qualitative analysis.

Table 8: Summary of t-test on the difference in mean rating on the level of acquisition of integrated science process skills by male and female secondary school Chemistry students in qualitative analysis

Gender	t-cal	t-crit	N	$\bar{x}$	SD	Do	t-
Male	0.07	1.97	140	2.67	1.18	273	
Female			135	2.68	1.11		

NS: Not Significant

Results from Table 8 showed that the t-calculated value of 0.07 is less than the t-critical value of 1.97 therefore the null hypothesis is accepted and the researchers conclude that there is no significant difference on the mean rating on the level of acquisition of integrated science process skills based on gender.

HO₄: There is no significant difference in the level of acquisition of integrated science process skills in qualitative analysis between secondary school Chemistry students in urban and rural schools.

Table 10: Summary of t-test on the difference in mean rating on the level of acquisition of integrated science process skills in qualitative analysis between urban and rural secondary school Chemistry students.

School location	N	$\bar{x}$	SD	Do	t-cal	t-crit	Remark
Urban	148	2.86	1.01	273	2.98	1.97	S
Rural	126	2.46	1.19				

S: Significant

Results from Table 10 indicates that the t-calculated value of 2.98 is greater than the t-critical value of 1.97 therefore, the null hypothesis is rejected and the researchers conclude that there is a significant difference on the mean rating on the level of acquisition of integrated science process skills based on school location.

Discussion

This study sought to determine the level of acquisition of basic and integrated science process skills by secondary school Chemistry students in qualitative analysis in Abakaliki Education Zone. They showed that the level of acquisition of the basic science process skills of observation, classification, measurement, communication and prediction was high ($\bar{x}=3.04$, $SD=1.17$). This agrees with the studies by Ugwuanyi and Wafer (2021) and Kamarudin, Wahid and Harare (2022) who report a high level of basic science process skills by Chemistry students. However, it negates the findings of the study by Herd, Johor, Madison, Ruse and Asher (2020) who report a low level of acquisition of basic science process skills among Chemistry students in qualitative analysis. The results also indicate that the level of acquisition of the integrated science process skills of controlling variables, manipulation, inference and interpretation of data was high ($\bar{x}= 2.67$, $SD=1.08$). This concurs with the studies by Kamiah and Adamou (2022) and Armani, Ratline, Kurniawan and Wiryudu (2022) who report a high level of integrated science process skills in qualitative analysis. However, the results disagree with the studies by Kamarudin, Wahid and Harare (2022); Kadar and Sane (2018) and Dario (2019) who found out that there was low acquisition of integrated science process skills. Also, the results from the study indicate that for the basic science process skills, the male Chemistry students had a higher mean rating ($\bar{x}=3.09$, $SD= 1.14$) than the female students ($\bar{x}= 2.90$, $SD=1.19$). This result was tested by the null hypothesis H_{01} at 0.05 level of significance and the results from Table 7 showed that there is no significant difference in the mean rating of the level of acquisition of basic science process skills between male and female secondary school Chemistry students. This agrees with the studies by Oyo and Tijuana (2025) and Anim-Eduful and Adu-Gyamfi (2022) who found that there was no significant difference in the level of acquisition of basic process skills in terms of gender but negates the studies by Irate, Rhaetia and Prodjosantoro (2018) and Revalthi and Malachi (2023) who report a significant difference in the acquisition of basic science process skills between male and female Chemistry students in favor of the female students while Cookson (2021) and Omak (2015) report a significant difference in favor of the male students. The study also shows that there is not much difference in the level of acquisition

of basic science process skills among secondary school Chemistry students in the urban schools ($\bar{x}$ =3.01, SD=1.14) and those in the rural schools ($\bar{x}$ =2.97, SD=2.97). This assertion was tested with the null hypothesis HO_2 and the results from Table 8 showed that there is no significant difference in the level of acquisition of basic process skills in terms of school location. This is due to the early exposure of students to the basic process skills from the primary level of education thereby improving their proficiency with time. The result agrees with the study by Obikezie, Onyebuche, Akachukwu and Neale (2025) and Escudo, Ugwuanyi and Amah (2022) but negates the study by Armani, Astatine, Kurniawan and Putrid (2022) who report a significant difference in the acquisition of basic science process skills between Chemistry students in urban and rural schools in favor of the urban schools.

In addition, the results of the study show that on the level of acquisition of integrated science process skills the female secondary school Chemistry students had a slightly higher mean ($\bar{x}$ =2.68, SD=1.11) than the male students ($\bar{x}$ =2.67, SD=1.18). This was tested by the null hypothesis HO_3 and it showed that there was no significant difference in the mean rating of the level of acquisition of integrated process skills. This is in concurrence with the study by Anim-Eduful and Adu-Gyamfi (2022) and Ugwuanyi and Wafer (2021) who found that there was no significant difference in the acquisition of integrated process skills. It disagrees with the studies Orator (2021) who reported a significant difference in the acquisition of integrated science process skills between male and female Chemistry students in favor of the females while Nikola, Aruba and Habinshuti (2022) report a significant difference in favor of the male students. Furthermore, the researchers found that the Chemistry students in the urban schools ($\bar{x}$ = 2.86, SD=1.01) had a higher mean rating on the level of acquisition of integrated science process skills than Chemistry students in the rural schools ($\bar{x}$ =2.46, SD=1.11). This was tested by the null hypothesis, HO_4 and it showed that there was a significant difference in the level of acquisition of integrated process skills. This is in agreement with the studies by Armani, Astatine, Kurniawan and Putrid (2022) who report a significant difference in the level of acquisition of integrated process skills in favor of Chemistry students in urban schools and Kamiah and Adamou (2022) who report a significant difference in favor of Chemistry students in rural schools. However, it disagrees with the studies by Escudo, Ugwuanyi and Amah (2019) who assert that there is no significant difference in the level of the acquisition of integrated science process skills based on school location.

Conclusion

From the findings of the research, the conclusion was drawn that there is a high level of acquisition of the basic science process skills of observation, communication, measurement, classification and prediction as well as the integrated science process skills of controlling variables, manipulation, inference and interpretation of data but there was a low level of acquisition of the skill of experimentation. The findings also show that there was no significant difference in the mean ratings of the level of basic science process skills in terms of gender and school location. Also, there was no significant difference in the acquisition of integrated science process skills based on gender. However, there is a significant difference in the mean rating of the level of acquisition of integrated science process skills of the Chemistry students in terms of school location in favor of schools in the urban areas.

Recommendations

The Ebony state secondary education board must ensure proper equipping and maintenance of Chemistry laboratories in secondary schools in the state irrespective of the school location. The curriculum planners must redesign the teaching and practice of analytic Chemistry (qualitative and quantitative analysis) should be done as early as junior secondary school to encourage proficiency of the students in both basic and integrated science process skills. Chemistry teachers should ensure the constant use of the laboratory in teaching Chemistry.

References

- [1] Alcan, F. (2021). Analytical Chemistry laboratory qualitative analysis process examinations: Links between experimental data and calculations. *JurnalUmrahPeuradeun*, 9(3), 719-741.
- [2] Anim-Eduful, B and Adu-Gyamfi, K. (2022). Factors influencing High School Chemistry Teachers' and Students' Teaching and Learning of Organic Qualitative Analysis: A Qualitative Study. *European Journal of Education Studies* 9(7) 194-216.
- [3] Anode, H.C.O. (2019). History and Philosophy of Science. Hacofofom Educational Books. Enugu, Nigeria.
- [4] Anglo, M.N and Adowa, S. (2015). Assessment of the utilization of basic and integrated science process skill in the teaching of Chemistry in senior secondary schools in Ebony State. *Journal of Science Teachers Association of Nigeria*. 50(1) 97-106
- [5] Yodeled, O.D (2018). Restructuring secondary school Chemistry education for sustainable development in Nigerian Developing economy. *African Journal of Chemistry Education* 8(2) 93-111
- [6] Aziz, N., Anglo, M.N and Agro, R.A. (2022). Computer-based Programmed instruction strategy and Tertiary institution students' achievement in Nigeria. *Journal of Education and Practice* 13(16) 169-179
- [7] Belk, K.E., Scandal, J.A., Nair, M.N., Zhang, Georamas, G., Elmore, R.J. (2025). Perspectives: The role of science in society. *Animal Frontiers*. 15 (1) 97-101.
- [8] Bozeman, E., Matangana, D and Mwesigye, D. (2022). Effects of School Location on Students' Achievement in Photosynthesis based on Concept Mapping Instructional Strategy. *Eurasian Journal of Science and Environmental Education*. 2 (1) 1-10.
- [9] Chellamani, K and Anjugam, R. (2024). Science Process Skills: A trend analysis of research. *The International Journal of Indian Psychology* 12(1) 772-780.
- [10] Armani, D., Astatine, A., Kurniawan, D. and Putrid, W.A. (2022). Science Process Skills and Critical Thinking ability assessed from students' gender. *Jurnal Pendidikan Fisika Indonesia* 18(1) 83-95.

- [11] Dario, R.C (2019). Basic and integrated Science Process Skills Acquisition and Science Achievement of 7th Grade learners. European Journal of Educational Studies.
- [12] Fee, A.H and Ababa, E.I. (2023). Effects of laboratory method on Student' Acquisition of science process skills in senior secondary school Chemistry in Delta State, Nigeria. European Journal of Education Studies 10(11) 264-299
- [13] Eke N.G and Denney, J. (2022). Enhancing Secondary School Students' Achievement in Chemistry using Peer Tutoring Instructional Strategy in Secondary Schools in Abita State. Rivers State University Journals of Education.295) 53-59.
- [14] Escudo, F.O., Ugwuanyi, A.A and Amah, R.F. (2019). Science Process Skills acquired by senior secondary school Chemistry students in qualitative analysis in Enugu Education Zone, Nigeria. Journal of Engineering and Applied Science.14(2) 5333-5338
- [15] Herd, A., Johor, A., Madison, M., Rudi, M. and Asher, R. (2020). Science Process Skills Ability Level of Senior High School Students in Learning Chemistry in Jambi. International Journal of Scientific and Technology Research.9 (4) 1829-1833.
- [16] Diego, K.J., Najd, C.O. and UGu, A.N. (2017). Development of science process skills among Nigerian secondary school science students and pupils: An opinion. International Journal of Chemistry Education.1 (2) 13-21.
- [17] Idea, M.A. (2017). A Comparative Study of Urban and Rural Students' Attitudes to Chemistry at Introductory Level in Ibadan, Oyo State, Nigeria. Journal of Scientific Research and Studies 4(7) 165-170.
- [18] Idea, M.A. (2017). Comparative study of urban and rural students 'attitude to Chemistry at introductory level in Ibadan, Oyo State, Nigeria. Journal of Scientific Research and Studies.4(7) 165-170
- [19] Irate, I., Rhaetia, E. and Prodjosantoro, A.K. (2018). The investigation of university students' science process skills and Chemistry attributes at the laboratory course. Asian-Pacific Forum on Science Learning and Teaching.19 (2) 1-22.
- [20] Myola, B.F. and Ezek, D.N. (2024). Students' attitude and Gender as determinants of colleges of education students 'academic achievement in Chemistry. Lafia Journal of Scientific and Industrial Research (LJSIR) 2(2) 90-95.
- [21] Jack, G.U and Japhet, J. (2020). Effects of multiple teaching strategy on students' academic achievement and attitudes towards Chemistry in Jailing education zone of Tarawa state, Nigeria. Ilorin Journal of Education.40.2020. 145-155.
- [22] Jack, G.U. (2018). Chemistry students' science process skills acquisition: Influence of gender and class size. Global Research in Higher Education.1 (1) 80-97.
- [23] Jagged, R.O and Keya, A.E. (2022). Influence of Environment on Rural Secondary School Students' Academic Performance in Chemistry in Equity State, Nigeria. International Journal of Academic Research in Business, Arts and Science.4(10) 1-13

- [24] Kadar, N.D and Sane, S.S. (2018).Science process skills acquisition level among form two students in one district of Sabah. Journal of Research, Policy and Practice of Teachers and Teacher Education.8 (1) 32-44.
- [25] Kamarudin, N., Wahid, M and Harare, S. (2022). Exploring Basic and Integrated science process skills and their impact on Science achievement among university students. Journal of Public Administration and Governance.12 (46) 74-90.
- [26] Kenni, A.M. (2020). Effect of class size on academic achievement of Chemistry students in Isere Local Government Area of Equity State, Nigeria.Awored-International Journal of Innovative Studies.1 (3) 26-38.
- [27] Kamiah, C.B and Adamou, J. (2022). Assessment of level of science process skills possessed by senior secondary school Chemistry students. African Journal of Science, Technology and Mathematics 8(2) 130-137.
- [28] Cookson, A. (2021). Assessing Acquired Science Process Skills of Senior High School in Central Region, Ghana. Advances in Social Sciences Research Journal 8(11) 438-451.
- [29] Muhammad, A.Z and Farkhunda, R.C. (2020).5E Instructional Model. A Constructivist Model for teaching Chemistry at Higher Secondary Level. Pakistan Journal of Education Research 3(2) 16-32.
- [30] Mullein, J., Tamaris, M and Supriyah, Y. (2019).Improving basic science process skills through inquiry-based approach on learning science for early elementary science. Journal of Turkish Science Education. 16(2) 187-201
- [31] Nikola, B.C., Aruba, E and Habinshuti, G. (2022). Students' perceived science inquiry skills in relation to school type and gender. Perspectives in Education.40 (2) 159-174.
- [32] Obikezie, M.C.,Onyebuchi, E.D., Akachukwu, E.E and Neale, H.O. (2025).School Locations and Gender Variables in Students' Science Process Skills as a Predictor of Academic Achievement in Senior Secondary School. Journal of Educational Research.4 (1) 1-7.
- [33] Ojo.O.T and Tijuana, B.E. (2025). Influence of Gender on Chemistry Student Acquisition of Science Process Skills across School type using Open Inquiry Instructional Strategy. African Multidisciplinary Journal of Development 13(2) 233-245.
- [34] Orator, N.P. (2021). Enhancing science process skills acquisition in Chemistry among secondary school students through context-based learning. Science Education International .32(4) 323-330.
- [35] Okonkwo, W., Oyo, N.O and Agro, I.C. (2022).School Location as Correlates of Students' Academic Achievement in Public Secondary Schools in Ebony State. IOSR Journal of Business and Management 24(1) 33-41.

- [36] Omak, A. (2015). Levels of possession of science process skills by final year students of colleges of education in South-Eastern States of Nigeria. *Journal of Education and Practice* 6(27)94-101.
- [37] Onasanya, S.A., Wuhu, K.M., Oladipupo, M.O., Samuel, N and Shoal, A.O. (2019). Effectiveness and Chemistry learning app for Nigerian undergraduates in a blended learning environment. *Al-Hikmah Journal of Education*. 6(1) 76-83.
- [38] Ngoro, R.O. (2017). Secondary school students' mastery of integrated science process skills in Saia County, Kenya. *Creative Education* (8) 1941-1956.
- [39] Revalthi, M and Malachi, S. (2022). An Analysis of Basic Science Process Skills among Secondary School Students in Rapine District. *Educational Administration: Theory and Practice* 29(4) 555-559.
- [40] Silvia, O., Olio, O.G., Bastion, R.D.A., Bastion, R.S and Demonic, S.D.M. (2024). Identification of captions, reactions and separation of Group 1 cations. *Journal of Global Research Education*, 2(1) 27-35.
- [41] Szydlo, A.Z. (2022). The beginnings of Chemistry: From ancient times until 1661. *Pure and Applied Chemistry*. 2022. 1-21.
- [42] Tegegne, T. A and Kalka, A. D. (2023). Comparative study of using 5E learning cycle and the traditional teaching method in Chemistry to improve student understanding of water concept: The case of primary school. *Cogent Education* 10 21996341-17
- [43] UGu, A.N. (2014). Factorial Validation of an instrument for the assessment of Practical Chemistry Skills Acquisition. *Journal of Education and Practice*. 5 (8) 175-185.
- [44] Ugwuanyi, A.A. and Wafer, S.C. (2021). Science process skills acquired by senior secondary school Chemistry students in qualitative analysis in Enugu Education Zone, Nigeria. *Unisia Journal of Educational Research and Policy Studies*. 7 (1) 518-533.
- [45] Paha, J.E., Gbadamosi, R and Boniface, V.E. (2017). Scientific Literacy themes coverage in the Nigerian senior school Chemistry curriculum's Turkish Science Education 14(2) 52-64.
- [46] Aside, R.K. and Patel, N. (2022). A study on effect of 7E learning cycle based programmed on integrated science process skills of secondary school students. *The International Journal of Analytical and Experimental modal analysis*. 14 (3) 486-491.
- [47] WAEC (2019) Chief Examiner's Report, Lagos: WAEC Press. Ltd