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ASSESSING THE LEVEL OF ACQUISITION OF BASIC AND INTEGRATED SCIENCE PROCESS SKILLS IN QUALITATIVE ANALYSIS AMONG SECONDARY SCHOOL CHEMISTRY STUDENTS IN EBONYI STATE, NIGERIA

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Abstract:
Chemistry students demonstrate poor performance and achievement in integrated science process skills, particularly when conducting qualitative analysis, despite the critical role of Chemistry in national development. This study explores the Level of Acquisition of Basic and Integrated Science Process Skills in Qualitative Analysis among Secondary School Chemistry Students in Ebonyi State, Nigeria. A descriptive cross-sectional survey design was used. The population of the study comprised two thousand, eight hundred and seventy-two (2872) Senior Secondary III Chemistry students. A multi-stage sampling technique was used to select a sample of 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. 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.

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1. 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 society. The developments in science are a testament to the ingenuity, curiousity, adventure and resilience of man. According to Tijani and Adeduyigbe (2025), science plays a crucial role in building a foundation for technological advancement, economic transformation and social progress. Belk, Scanga, Nair, Zhang, Georgaras and Delmore (2025) define science as the use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated. Science reaches out to new ideas and facts which contribute to the ever-growing stack of knowledge and provide children with the opportunities to grow their innate curiousity and discovery about the natural world (Mulyeni, Jamaris and Supriyah, 2019). According to Nikol, Gakuba and Habinchuli (2022), science is learnt as a process and a product, although these two are not always accorded equal attention in the learning process. Therefore, Keziah and Adamu (2022) assert that science teaching, especially the learning of Chemistry, should be an active and constructive process which enables knowledge construction required for active participation on the part of the learners.

Chemistry is a fundamental science subject which is included in the science curriculum of 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 & Kelkay, 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 Nwafor (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) (Efe & Abamba, 2023). Therefore, Chemistry is a prerequisite subject for offering most science-oriented courses in the tertiary institutions (Eke & Dinneya, 2022). Chemistry is a practical subject structured around four (4) themes: the chemical world; chemistry and the environment; chemistry and industry; chemistry and life (Upahi, 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 (Idiege, Nja and Ugwu, 2017). It provides a framework of

how scientists think, work and study problems as well as seek solutions in a scientific manner. According to Vasudev and Patil (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) (Asogwa & Anugwo, 2015).

Idiege, Nja and Ugwu (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 & Nwafor, 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 Alkan (2021), qualitative analysis determines which chemicals a sample contains, whereas quantitative analysis allows for determining which (how much) of these chemicals are numerically present in a sample. Silvia, Olia, Nasution, Nasution and Damanik (2024) state that qualitative analysis is a 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 (Efe & Abamba, 2023). Also, Anaso (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. Kenni (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 require science process skills suggests that gender segregation in the education and labour market remains persistent. Orji, Okeke, Ilo, Nwosu 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 (Azih, Anugwo and Agor, 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 classwork and studying, leading to a loss of interest and poor attitude (Idika, 2017). Interestingly, Muhammed and Farkhunda (2020) report a vivid discrimination between girls and boys in the teaching and learning of Chemistry. However, Jack and Japhet (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 & Japhet, 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 instruction are inimical to the acquisition of science process skills in Chemistry. This is very common in rural secondary schools. Bizimana, Matagana and Mwesiga (2022) assert that the location of a school plays a major role in the students' achievement in science. Okonkwo, Oko and Agor (2022) define school location as the place where a school is sited, either in a rural or urban area. Jegede and Okeya (2022) identify 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 and poor lighting in classrooms. On the other hand, urban areas have moderate population, electricity, water supply, better learning facilities and more teachers (Obi, Agiande and Ugbe, 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 (Allahnana, Akande, Vintseh, Alaku and Alaku, 2018).

2. 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 Iyiola and Ezeh (2024) report that in most secondary schools, Chemistry is taught as a bundle of abstractions without practical experiences. This has resulted in 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 the 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, an inability to deduce inferences from observations, an 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 Ebonyi State and how this can be affected by gender and school location.

The objective of the study was to: (a) Ascertain the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis, (b) Determine the level of acquisition of integrated science process skills by secondary school Chemistry students in qualitative analysis, (c) Ascertain the level of acquisition of basic science process skills by secondary school Chemistry students in qualitative analysis in terms of gender, (d) Ascertain the level of acquisition of basic science process skills by secondary school Chemistry students in terms of school location, (e) Find out the level of acquisition of integrated science process skills by secondary school Chemistry students in terms of gender, (f) Determine the level of acquisition of integrated science process skills by secondary school Chemistry students in terms of school location.

3. Methodology

The study adopted a descriptive cross-sectional survey design. The area of study was the Abakaliki Education Zone of Ebonyi State. 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. A 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 adaptedfromUgwu (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 Ebonyi State University, Abakaliki. The instrument was trial tested on ten (10) students chosen from a different secondary school in the Afikpo Education Zone of Ebonyi 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, the Cronbach 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 3.1or less than or equal to equal 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.

5. 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 the gas evolved upon heating the mixture on the colour of litmus paper	275	3.03	1.16	VGE	High
3	Detecting the effervescence of gas when a solution is added to the residue	275	3.08	1.24	VGE	High
	Cluster Mean		**3.08**	**1.18**	**VGE**	**High**
Classification Skills						
4	Separating mixtures by the filtering process	275	3.69	0.65	VGE	High
5	Grouping gases according to their odour	275	2.88	1.19	GE	High
6	Writing down an inference based on the observation	275	3.02	1.15	GE	High
	Cluster Mean		**3.20**	**0.99**	**VGE**	**High**

Measurement Skills						
7	Estimating quantities of the required sample to be added	275	2.91	.863	GE	High
8	Estimating the quantity of the drop of the reagent to be added initially, before excess	275	2.77	1.02	GE	High
9	Correctly adding the exact recommended amount of distilled water (10ml) to the sample	275	2.75	1.29	GE	High
	Cluster Mean		**2.81**	**1.06**	**GE**	**High**
Communication Skills						
10	Using correct technical terms in reporting results of an experiment e.g dissolves/soluble instead of melts	275	3.16	1.04	VGE	High
11	Describing briefly the observation made	275	3.07	1.17	VGE	High
12	Using the correct chemical symbol, formulae and ions in recording test carried out	275	2.98	1.21	GE	High
	Cluster Mean		**3.07**	**1.14**	**GE**	**High**
Prediction Skills						
13	Suspecting the ions correctly in a sample of salt from the observation made before the confirmatory test	275	2.84	1.20	GE	High
14	Suspecting the compound (s) correctly in a sample of salt given from the physical state of the sample	275	2.75	1.34	GE	High
15	Suspecting the nature of the gas evolved	275	2.81	1.21	GE	High
	Cluster Mean		**2.80**	**1.25**	**GE**	**High**
	Overall mean		**3.04**	**1.17**	**GE**	**High**

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 afterthe addition of a reagent to a substance in the test tube	275	3.54	0.85	VGE	High
	Cluster Mean		**2.84**	**0.96**	**GE**	**High**
Experimenting Skills						
19	Setting up the heating apparatus	275	2.07	0.97	GE	High
20	Holding a test tube in a slanting position with a test tube holder while heating	275	1.99	1.03	LE	Low
21	Heating a 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 colour, odour 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 evolved 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 the 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				Female			
		N	$\bar{x}$	SD	Level	N	$\bar{x}$	SD.	Level
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 the gas evolved upon heating the mixture on the colour of litmus paper	140	3.09	1.13	High	135	2.97	1.19	High
3	Detecting the 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 the filtering process	140	3.67	0.68	High	135	3.70	0.61	High
5	Grouping gases according to their odour	140	2.99	1.18	High	135	2.76	1.19	High
6	Writing down an 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 the drop of reagent to be added initially before excess	140	2.90	0.98	High	135	2.64	1.04	High
9	Correctly adding the 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 an 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, and ions in recording tests 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 the ions correctly in a sample of salt from the observation made before the confirmatory test	140	2.91	1.13	High	135	2.77	1.27	High
14	Suspecting the compound(s) correctly 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 the nature of the 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, HO_1 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				Urban			
		N	$\bar{x}$	SD	Level	N	$\bar{x}$	SD	Level
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 the gas evolved upon heating the mixture on the colour of litmus paper	127	2.98	1.27	High	148	3.07	1.05	High
3	Detecting the 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 the filtering process	127	3.79	0.60	High	148	3.60	0.68	High
5	Grouping gases according to their odour	127	2.87	1.26	High	148	2.89	1.13	High
6	Writing down an 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 the drop of reagent to be added initially before excess	127	2.65	0.98	**High**	148	2.89	1.03	High
9	Correctly adding the exact recommended amount of distilled water (10ml) to the sample	127	2.48	1.30	High	148	2.98	1.242	High
	Cluster mean		**2.68**	**1.03**	**High**		**2.93**	**1.06**	**High**
Communication Skills									
10	Using correct technical terms in reporting results of an 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 and ions in recording the 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 the ions correctly in a sample of salt from the observation made before the confirmatory test	127	2.84	1.27	High	148	2.84	1.14	High
14	Suspecting the compound(s) correctly 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 the nature of the 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 ($\bar{x} = 2.97, \text{SD} = 1.24$) when compared to students in the urban schools ($\bar{x} = 3.01, \text{SD} = 1.14$). 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, HO_2 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 in 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 the addition of a reagent to a substance in the 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 the heating apparatus	140	1.89	0.91	Low	135	2.27	0.99	High
5	Holding a test tube in a slanting position with a test tube holder while heating	140	1.80	1.03	Low	135	2.19	1.00	High
6	Heating a 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 gas evolved on heating	140	2.85	1.08	High	135	2.82	0.99	High
9	Handing the 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 colour, odour 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 the 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, HO_3 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 the school location

S/n	Items	Rural				Urban			
		N	$\bar{x}$	SD	Level	N	$\bar{x}$	SD	Level
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 afterthe addition of a reagent to a substance in the 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 the heating apparatus	127	1.72	0.84	Low	148	2.38	0.97	High
5	Holding a test tube in a slanting position with a test tube holder while heating	127	1.62	0.90	Low	148	2.30	1.03	High
6	Heating a 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	Handing the 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 colour, odour or actions on some compound	127	2.69	1.25	High	148	2.81	1.13	High
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 evolved 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 the 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 HO_4 to find out if the difference was significant.

HO_1: 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	Dft-cal	t-cal	t-crit	Remark
Male	140	3.09	1.14	273	1.35	1.97	NS
Female	135	2.90	1.19				

Note: NS = Not Significant.

The results from Table 7 show that the t-calculated value of 1.35 is less than the t-critical value of 1.97, 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.

HO_2: 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	Df	t-cal	t-crit	Remark
Urban	148	3.01	1.14	273	0.28	1.97	NS
Rural	127	2.97	1.24				

Note: 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 in the mean rating on the level of acquisition of basic science process skills by secondary school Chemistry students based on school location.

HO_3: 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

School Location	N	$\bar{x}$	SD	Df	t-cal	t-crit	Remark
Urban	140	2.67	1.18	2.73	0.07	1.97	NS
Rural	135	2.68	1.11				

Note: 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 in the mean rating on the level of acquisition of integrated science process skills based on gender.

HO_4: 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 the 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	Df	t-cal	t-crit	Remark
Urban	148	2.86	1.01	273	2.98	1.97	S
Rural	126	2.46	1.19				

Note: S = Significant.

Results from Table 10 indicate 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 in the mean rating on the level of acquisition of integrated science process skills based on school location.

6. 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. The study 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 Nwafor (2021) and Kamarudin, Wahida and Ahrari (2022), who report a high level of basic science process skills by Chemistry students. However, it negates the findings of the study by Herda, Johari, Maison, Rusi and Asyhar (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 Keziah and Adamu (2022) and Darmaji, Artalini, Kurniiawan and Wiriyudu (2022), who report a high level of integrated science process skills in qualitative analysis. However, the results disagree with the studies by Kamarudin, Wahida and Ahrari (2022); Kahar and Sani (2018) and Derilo (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 HO_1 at a 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 Ojo and Tijani (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 Irwanto, Rohaeti and Prodjosantoro (2018) and Revalthi and Malathi (2023) who report a significant difference in the acquisition of basic science process skills between male and female Chemistry students in favour of the female students while Koomson (2021) and Omiko (2015) report a significant difference in favour 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 Nnalue (2025)

and Ezeudu, Ugwuanyi and Ameh (2022) but negates the study by Darmaji, Astalini, Kurniawan and Putri (2022) who report a significant difference in the acquisition of basic science process skills between Chemistry students in urban and rural schools in favour 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 Nwafor (2021), who found that there was no significant difference in the acquisition of integrated process skills. It disagrees with the studies of Okafor (2021), who reported a significant difference in the acquisition of integrated science process skills between male and female Chemistry students in favour of the females, while Nikol, Gakuba and Habinshuti (2022) report a significant difference in favour 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 Darmaji, Astalini, Kurniawan and Putri (2022), who report a significant difference in the level of acquisition of integrated process skills in favour of Chemistry students in urban schools and Keziah and Adamu (2022), who report a significant difference in favour of Chemistry students in rural schools. However, it disagrees with the studies by Ezeudu, Ugwuanyi and Ameh (2019) who assert that there is no significant difference in the level of the acquisition of integrated science process skills based on school location.

7. Conclusion

This study concludes that there wasa 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 favour of schools in the urban areas.

7.1 Recommendations

The Ebonyi 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) to be done as early as junior secondary school to encourage the 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.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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