Do West African Senior School Certificate Chemistry Practical Examination Questions Promote Utilization of Higher-order Science Process Skills?

Ayoade Ejiwale Okanlawon
Department of Science, Technology, and Mathematics Education,
Osun State University at Ipetu-Ijesa, Ipetu Ijesa, Nigeria

Abstract

This paper is aimed at responding to a question which state that "do senior school certificate examination on practical chemistry promote utilization of higher-order science process skills?" Therefore, in responding to this question chemistry practical examination questions between the periods of 2009 and 2013 were subjected to content analysis. The analysis involved coding in which the examination questions were read line –by-line to identify the science process skills to be utilized in carrying out the laboratory activities that were required in answering examination questions. Two independent coders coded the laboratory activities and the inter-rater reliability was high enough. The major results emerging from this study were that fewer laboratory activities require students to operate at higher-level of science process skills. Based on the results, the investigator recommended that practical examination questions that provide students with the opportunities to design, develop and conduct their own experiment should be utilized.

1. Introduction

Science can be conceived as a process of inquiring and investigation. It is also a way of thinking and acting, not just a body of knowledge to be acquired by memorizing facts and principles. This way of thinking, the science method, demand for a practical examination questions that would subject students to investigational activities which include posing questions, designing experiments, collecting, analyzing and interpreting data, and drawing conclusions. Critical to understanding science a concept is the use of scientific inquiry to develop explanations of natural phenomena. Therefore, acquisition of science process skills is a prerequisite for carrying out laboratory activities. Those promoting an enquiry-based approach to science education argued that if students were to learn about how science works, then they needed to develop an understanding of the processes of science. That is, the skills used in doing investigational works. In order to construct knowledge on their own and to acquire higher-order cognitive skills, students need to study in laboratory environment that brings science process skill in prominence. It is often argued that practical work is central to teaching and learning science and that good quality practical work helps develop students' understanding of scientific processes and concepts [1].

As conceived by Nwosu and Okeke[2], science process skills are mental and physical abilities and competencies which serve as tools needed for the effective study of science and technology as well as problem solving, individual and societal development. Science process skills include: observing, measuring, classifying, communicating, predicting, inferring, using number, using space/time relationship, questioning, controlling variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data as specified by the American Association for the Advancement of Science (AAAS) [3]. These skills are often dichotomized into basic and integrated science process skills. The basic (lower-order) process skill provide a prerequisite knowledge for learning the integrated (higher-order) process skills. Science process skills form the basis of the ability to carry out specific chemistry practical activities during practical examinations. The West African Examinations Council's (WAEC) test items developers assess senior school students' acquisition of various chemistry practical skills using practical examination questions. Surprisingly, most school science practical classes and practical assessment are based on content (i.e., following specific procedures to collect data) and virtually no emphasis on planning scientific investigations or interpreting results. In such situations students are prevented from engaging in activities involving the use of higher-order science process skills. In order to verify the claim that traditional laboratory assessment does little to develop the higher-order science process skills of students, a content analysis of five (5) senior school certificate chemistry practical examination questions papers was carried out. This research was guided by two research questions:

1. At what level of science process skills do the chemistry practical examination questions require the students to operate?
2. What are the proportions of lower-order and higher-order science process skills included in the senior school certificate chemistry practical examination questions?

2. Review of related literature

In promoting effective science instruction in schools, American Association for Advancement of Science [3] and National Research Council [4] have outlined specific guidelines for teachers' use. Three broad areas, namely; science understanding, inquiry and discourse are included in these guidelines.

To enable students to engage in science understanding and inquiry, teachers must be properly equipped with scientific process skills, possess adequate knowledge of science contents and effective instructional strategies. In a situation, in which much emphasis is on scientific content rather than on process of science, students failed to develop a scientific way of thinking – a way of constructing new ideas that illuminate the world around us. As the National Research Council[4] stated, " A classroom in which students use sciences process skills in generating knowledge is one that resembles those that research has found the most effective for learning for understanding". Consequently, students become autonomous learners if they become aware of the process of learning itself, including strategies for consolidating new materials and for checking their understanding [5].

Science education literature reveals that science process skills are component of and essential to acquisition of knowledge in other disciplines. For instance, Simon and Zimmerman [6] found that teaching science process skills enhances oral and communication skills of students. Similarly, Shann [7] found that teaching science process skills enhances problem-solving skills in mathematics. They can be acquired and develop in students through exposure to science practical activities and practical assessments infuse with science process skills. These skills are classified into two groups as shown in Table 1 and 2.

Table 1. Basic (lower – order) science process skills and Definitions

S/N	Skills	Code	Definition/ Operational Description
1.	Observing	OBS	This involves the use of senses to gather information about an object or event. It is a description of what was actually perceived where direct sense experience is not adequate for making needed observations, indirect methods are used.
2.	Classifying	CLF	This is a systematic procedure used to group or order objects or events into categories based upon characteristics or defined criteria.
3.	Measuring	MEA	This is a process of assigning a number or a sign to express in quantitative terms the degree to which an object or an event possesses a given characteristics.
4.	Communicating	CMT	This is a process of transmitting information from one person to another using any one of several procedures (e.g. words, symbols or graphics).
5.	Inferring	INF	This involves explaining observation in terms of previous experiences.
6.	Predicting	PRD	This involves formulation of future outcomes base upon a pattern of evidence.
7.	Algorithmic problem solving	APS	This involves application of an algorithm or formula ($n = m/M$, $C = n/v$) to solve routine problem. The problems are normally posed in such a way that the student is able to determine the type of response that is acceptable.
8.	Comparing	CMP	This involves comparing information within or across data set or texts.

Table 2. Integrated (higher–order) science process skills and Definitions

S/N	Skills	Code	Definition/ Operational Description
1.	Manipulating	MAP	Activity by which students use the movement of various muscles to accomplish a task.
2.	Questioning	QUE	This is the ability to raise problems or points for investigation or decision.
3.	Investigating	INV	This involves planning and conducting a series of data-gathering operations which will provide a basis for testing an hypothesis or answering a questions.
4.	Decision – Making	DMK	This is the process of establishing and applying criteria to select from equally attractive alternatives. The process of establishing criteria involves consideration of the consequences and values.
5.	Interpreting	INT	This involves finding a pattern in a collection of data which leads to a generalization.
6.	Creative problem solving	CPS	This is a process of analyzing a problem and choosing a novel but relevant solution in order to remedy a problem situation.
7.	Organizing Data in Table	ODT	This involves making data tables in present lab reports.
8.	Experimenting	EXP	This is a process of carrying out on experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times.

Having established the positive effects of science process skills on learners' academic abilities, the need to encourage its utilization in science practical examination becomes imperative.

3. Methodology

The ex-post facto design is adopted in this qualitative study. In researcher's view this research design is considered suitable because the study involves content analysis of chemistry practical examination questions constructed by the WAEC between the periods of 2009 – 2013. Content analysis is described as a research technique for objective, systematic and quantitative description of the manifest content of a document. In this study, the documents are senior school certificate chemistry practical examination questions.

Senior school certificate chemistry practical examination questions constructed by the WAEC between the periods of 2009 – 20013 were purposively selected as sample for this study because these are the most recent questions.

The May/June chemistry practical examination questions (Alternative A) were collected from the publication Department of the Zonal Office of the West African Examinations Council at Osogbo, Osun State, Nigeria. Prior to the data collection, letter requesting for the chemistry practical examination questions was sent to the Head of the publication Department of facilitate data collection.

The collection data, the chemistry practical examination questions were subjected to content analysis. The analysis involved coding in which the practical examination questions were read line – by – line to identify the science process skills to be employed in carrying out the laboratory activities prescribed in the examination questions. Thereafter, codes were assigned to the identified science process skills. The coding process is illustrated in the Appendix.

In order to guarantee the reliability of the result, two coders (the researchers and a chemistry educator) individually coded five groups (which correspond to the year of examination) of chemistry practical examination questions, compared classification and resolve differences in categorization via discussion. Several rounds of classifications, confirmation and modification were conducted to satisfactorily summarize the date presented in Table 3 and 4. Following the discussion, the percentage agreement was calculated for each year: for 2009, 85.4% (concordance) was obtained; for 2010, 84.4% (concordance) was obtained; for 2011, 90.4% (Concordance) was obtained; for 2012, 86.5% (concordance) was obtained; and for 2013, 91.3% (concordance) was obtained. Prior to the peer review, the coding procedure was demonstrated by the coders in which some sample chemistry practical examination questions taken from the National Examinations

Council (NECO) examination papers were coded. Embarking on this exercise ahead of the actual coding process is aimed at enabling the coders to have a good understanding of the coding process.

4. Findings

Findings of this study are based on a content analysis of West African Senior School Certificate Chemistry practical examination questions between the periods of 2009-2013. For clarity purpose, the findings (see Table 3 and 4) were presented according to each research question.

Research Question 1: At what level of science process skills do the chemistry practical examination questions require the students to operate?

The outcome of the content analysis of chemistry practical examination questions constructed between the periods of 2009-2013 provided answer to this question. As revealed in 3, large proportion, of the laboratory activities require the final year senior secondary school chemistry students to operate predominantly at the lower-level of science process skills (i.e., Basic science process skills).For instance, majority of the practical activities to be carried out by the students in answering the chemistry practical examination questions required the use of basic science process skills such as observing, measuring, inferring, communicating and algorithmic problem solving.

Research Question 2: What are the proportions of lower-order and higher-order science process skills included in the senior school certificate chemistry practical examination questions constructed the WAEC between the periods of 2009-2013.

Similarly, the answer to this question is based on the outcome of the content analysis of chemistry practical examination questions. As shown in Table 3 and 4, 73.4 % and 26.6 % of the basic (lower-level) science process skills and integrated (higher-level) science process skills respectively were included in the laboratory activities necessary to be performed by the test takers in answering the chemistry practical examination questions respectively.

The result of qualitative analysis presented in Table 4 reveals that, among the basic (lower-order) science process skills necessary for performing laboratory activities as required by the practical examination questions, observing was featured highest with a frequency of 66(28.0%), seconded by inferring with a frequency of 35 (14.8%), followed by algorithmic problem solving with a frequency of 21(8.9%). Both communicating (with a frequency of 10 representing 4.2%) and comparing (with a frequency of 10 representing 4.2%) were less involved in the laboratory activities. While classifying and predicting were totally deemphasized the utilization of in the laboratory due to the nature of chemistry practical examination questions designed for the final year school students.

The analysis in Table 3 and 4 also indicates that, among integrated (higher-order)science process skills necessary for carrying out laboratory activities as demanded by the chemistry practical examination questions manipulating was featured highest with a frequency of 43(18.2%) and followed by organizing data in table and experimenting with each skill having a frequency of 10 presenting 4.2%. other integrated (higher-order) science process skills such as questioning investigating, decision making interpreting and creature problem solving were not involved in performing laboratory activities(as revealed in the appendix).

5. Discussion

Significantly fewer laboratory activities (that were necessary in answering chemistry practical examination questions) require students to operate at higher level of sciences process skills. In other words, the examinations failed to foster utilization of higher-order process skills which are closely related to higher-order thinking skills. These skills include meta-cognition, inferring information from context, de-contextualizing information and information synthesis [8]. Some earlier studies had reported similar findings. For example, Okebukola [9] reported that students were given few opportunities to acquire the science process skills and such few opportunities were mainly focusing on acquisition of lower pro-order process skills. It should be realized that when students are given opportunities to develop higher-order skills then are more equipped to mimic what ‘real’ scientist do and to develop a deeper understanding of every science content area.

From pedagogical perspective, the researcher considered the finding that there was a high involvement of basic science process skills to be appropriate to some extent. This is because secondary school students have not cognitively matured. This claim is supported by Chiapetta’s [10] observation which states that most early adolescents and many young adults have not yet reached their full formal reasoning capacity.

Table 3. Basic and integrated science process skills in the West African Senior School Certificate Chemistry Practical Examination between the periods of 2009 – 2013.

Year of examination	Nature of practical activities	Science process skills																TOTAL
		[a]Basic (lower – order) science process skills								[b]Integrated (higher – order) science process skills								
		OBS	**CLF**	**MEA**	**CMT**	**INF**	**PRD**	**APS**	**CMP**	**MAP**	**QUE**	**INV**	**DMK**	**INT**	**CPS**	**ODT**	**EXP**	
2009	Titrimetric Analysis	+ (5)	- (0)	+ (3)	+ (1)	- (0)	- (0)	+ (4)	+ (1)	+ (4)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Qualitative Analysis	+ (8)	- (0)	+ (3)	+ (1)	+ (8)	- (0)	- (0)	- (0)	+ (3)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Total	+(13)	- (0)	+(6)	+ (2)	+ (8)	- (0)	+ (4)	+ (1)	+ (7)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (2)	+ (2)	45
2010	Titrimetric Analysis	+ (5)	- (0)	+ (3)	+ (1)	- (0)	- (0)	+ (4)	+ (1)	+ (4)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Qualitative Analysis	+ (7)	- (0)	+ (4)	+ (1)	+ (3)	- (0)	- (0)	- (0)	+ (6)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Total	+(12)	- (0)	+(7)	+ (2)	+ (3)	- (0)	+ (4)	+ (1)	+(10)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (2)	+ (2)	43
2011	Titrimetric Analysis	+ (5)	- (0)	+ (3)	+ (1)	- (0)	- (0)	+ (4)	+ (1)	+ (4)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Qualitative Analysis	+ (7)	- (0)	+ (5)	+ (1)	+ (7)	- (0)	- (0)	- (0)	+ (5)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Total	+(12)	- (0)	+(8)	+ (2)	+ (7)	- (0)	+ (4)	+ (1)	+ (9)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (2)	+ (2)	47
2012	Titrimetric Analysis	+ (5)	- (0)	+ (3)	+ (1)	- (0)	- (0)	+ (4)	+ (1)	+ (4)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Qualitative Analysis	+(11)	- (0)	+ (5)	+ (1)	+(10)	- (0)	- (0)	- (0)	+ (4)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Total	+(16)	- (0)	+(8)	+ (2)	+(10)	- (0)	+ (4)	+ (1)	+ (8)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (2)	+ (2)	53
2013	Titrimetric Analysis	+ (5)	- (0)	+ (3)	+ (1)	- (0)	- (0)	+ (5)	+ (1)	+ (4)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Qualitative Analysis	+ (8)	- (0)	+ (3)	+ (1)	+ (8)	- (0)	- (0)	- (0)	+ (5)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (1)	+ (1)	
	Total	+(13)	- (0)	+(6)	+ (2)	+ (8)	- (0)	+ (5)	+ (1)	+ (9)	- (0)	- (0)	- (0)	- (0)	- (0)	+ (2)	+ (2)	48
Final	**Total**	**66(28.0%)**	**0(0.0%)**	**35(14.8%)**	**10(4.2%)**	**36(15.3%)**	**0(0.0%)**	**21(8.9%)**	**5(2.1%)**	**43(18.2%)**	**0(0.0%)**	**0(0.0%)**	**0(0.0%)**	**0(0.0%)**	**0(0.0%)**	**10(4.2%)**	**10(4.2%)**	**236**

[a]OBS**:** Observing, CLF: Classifying: MEA: Measuring; CMT: Communicating; INF: Inferring; PRD: Predicting; APS: Algorithmic problem solving; CMP: Comparing.
[b]MAP: Manipulating: QUE: Questioning; INV: Investigating: DMK: Decision – making; INT: Interpreting; CPS: Creative problem Solving; ODT: Organizing Data in Tables; EXP: Experimenting.
- Indicates skill is required; - indicates skill is not required.
Figures in brackets indicate the frequency in which the skills are required

Table 4. Summary of the basic (lower – order) and integrated (higher – order) science process skills in the West African Senior School Certificate chemistry practical examination between the periods of 2009 – 2013

S/N	**Basic Process Skills**	**Code**	**F(%)**	**S/N**	**Integrated Process Skills**	**Code**	**F(%)**
1.	Observing	OBS	66(28.0%)	1.	Manipulating	MAP	43(18.2%)
2.	Classifying	CLF	0(0.0%)	2.	Questioning	QUE	0(0.0%)
3.	Measuring	MEA	35(14.8%)	3.	Investigating	INV	0(0.0%)
4.	Communicating	CMT	10(4.2%)	4.	Decision – making	DMK	0(0.0%)
5.	Inferring	INF	36(15.3%)	5.	Interpreting	INT	0(0.0%)
6.	Predicting	PRD	0(0.0%)	6.	Creative problem solving	CPS	0(0.0%)
7.	Algorithmic problem solving	APS	21(8.9%)	7.	Organizing data in Tables	ODT	10(4.2%)
8.	Comparing	CMP	5(2.1%)	8.	Experimenting	EXP	10(4.2%)

F indicates the frequency at which a particular skill is used in carrying out laboratory activities.

6. Conclusion

This current study has arrived at the following specific findings:

1. There was a high demand for the utilization of basic (lower-order) science process skills in performing laboratory activities needed for answering chemistry practical examination questions constructed by the WAEC between the periods of 2009-2013.
2. Out of the 16 science process skills that were examined in this study, manipulating skills is the only prominent skills from the domain of higher-order process skills while observing, inferring and measuring are the most utilized basic process skills.

7. References

[1] T.H. Anderson, D.P., West, O.K. A text analysis of two pre-secondary science activities. *Journal of Curriculum Studies.* 1994, pp. 163-186.

[2] A.A. Nwosu, and E.A.C. Okeke, The effect of teacher sensitization of students' acquisitions of science process skills, *Journal of Science Teacher Association of Nigeria (STAN)*. 1995, pp 39-45.

[3] American Association for the Advancement of Science (AAAS). *Benchmarks for Science literacy:* Oxford University Press. New York. 1994.

[4] National Research Council. *Inquiry and the National Science Education Standards: A guide for teaching and learning*, National Academy Press, Washington, D.C. 2000.

[5] Uno, G.E. *Handbook on teaching undergraduate science course: A survival training manual*. Fort worth, TX: Harcourt Brace. 1999.

[6] M.S, Simon, and J.M, Zimmerman, Science and writing. *Science and Children*. 1990. pp. 7-8.

[7] M.H. Shann, Evaluation of interdisciplinary problem solving curriculum in elementary science and mathematics. *Science Education*. 1977. pp 491-502.

[8] S. Pogrow, Using higher-order thinking skills to overcome the cognitive wall: helping disadvantaged students meet standards in grades 4-8, *Leadership Journal.*, 2001, pp 35-40.

[9] P.A. Okebukola. Level of process skills development among students and implications for sciencing in Nigeria. *Proceedings of 26th annual conference of STAN.* 1985, pp. 217-218.

[10] E. Chiapelta,. A review of piagetian studies relevant to science instruction at the secondary and college level. *Science Education*, 1976. pp. 253-261.

Appendix

Questions: 1

All your burrette readings (initial and final) as well as the size of your pipette must be recorded but no account of experimental procedure is required. All calculations must be done in your answer book.

E is a solution of an acid HX containing 7.88g dm^{-3}
F is 0.125 mol dm^{-3} NaOH solution.

(a) Put **E** into the burrette and titrate it against 20.0cm^3 or 25.0cm^3 portions of **F** using methyl orange as indicator. Record the volume of your pipette. Tabulate your burrette readings. Repeat the exercise to obtain at least two consistent titre values. Calculate the average volume of **E** used.
The equation for the reaction involved in the titration is:

$$HX_{(aq)} + NaOH_{(aq)} \rightarrow NaX_{(aq)} + H_2O_{(l)}$$

(b) From your results and the information provided above, calculate the:
   (i) concentration of **E** in mol dm^{-3}
   (ii) molar mass of HX;
   (iii) mass of HX required to prepare $1.00dm^3$ of a solution containing 1.25mol dm^{-3}

Science Process Skills Involved
Basic (lower-order) Process Skills: **Observing, Measuring, Communicating, Comparing, Algorithmic problem solving**
Integrated (higher-order) Process Skills: **Manipulating, Organizing Data in Table, Experimenting**

Justification for the identified skills

- Delivering an accurate volume ($20.0cm^3$ or $25.0cm^3$) of F into conical flask (**required manipulating**).
- Measuring the required quantity ($20.0cm^3$ or $25.0cm^3$) of F using pipette (**required measuring**).
- Locating the position of meniscus to avoid parallax when reading pipette (**required observing**).
- Adding a few drops of methyl orange to F in conical flask (reaction vessel) (**required manipulating**).
- Noticing the colour of methyl orange in basic solution ($NaOH_{aq}$) (**required observing**).
- Setting up of apparatus for performing titrimetric analysis (**required manipulating**).
- Adding titrant (E) to analyte (F) until the reaction is complete required the following activities as described (**required manipulating):** solution from burette is run into the reaction vessel, which is swirled throughout the titration so that all parts of the mixture reach the end- point simultaneously. The left hand open the burette tap and the right hand holds the reaction vessel (flask) by the neck, imparting a swirling motion. Adding is rapid at first, but, as the indicator takes longer to revert to its original colour (with approach of the end-point) progressively decreasing volumes are added. Single drops, each about 0.05mL, or even half -drops, are added in the last stages. As the end – point is approached, a wash-bottle is used to wash down half- drops from burrette tip and solution sticking to the inside of the flask. End-point is reached when a permanent colour change for at least 30 seconds is noticed (**Manipulating skills is displayed**).
- Locating the position of meniscus to avoid parallax when reading burette (**required observing**).
- Reading a burette with repeatable precision of $\pm$0.01mL (**required measuring**).
- Recording the volume at which neutralization has taken place. For example cm^3 of solution **F** required $\_cm^3$ of solution **E** for complete reaction (**required communicating**).
- Monitoring the point (volume) at which neutralization has taken place (**required observing**) – because permanent colour change for at least 30 seconds in noticed.
- Ensuring that the titre values for 2 or 3 titrations agree to within 0.10mL (**required comparing**).
- Presenting titration reports clearly and correctly with the aid of Titration.
- Calculating the average volume of titrant (**E**) used (**required Algorithmic Problem Solving**).
- Calculating concentration of E in mol.dm^{-3} (**required Algorithmic Problem Solving**).
- Determining the molar mass of HX (**required Algorithmic Problem Solving**).
- Calculating mass of HX required to prepare $1.00dm^3$ of a solution containing 1.25mol.dm^{-3} (**required Algorithmic Problem Solving**).

Table (illustrated below)
(**required Organizing Data in Table**)

	Rough	Accurate		
		1st	2nd	3rd
Final reading (cm^3)				
Initial reading (cm^3)				
Titre (cm^3)				

Question 2: Credit will be given for strict adherence to the instructions, for observations precisely recorded and for accurate inferences. All tests, observations and inferences must be clearly entered in your answer book, in ink at the time they are made.

G is a mixture of a simple salt and a metal. Carry out the following exercises on **G**. Record your observations and identify any gases evolved. State the conclusion you draw from the result of **each** test.

(a) Transfer **G** into a beaker and add about $20cm^3$ of distilled water. Stir thoroughly and filter. Keep both the filtrate and the residue.
(b) (i) Pour one half of the filtrate into a boiling tube and add sodium hydroxide solution in drops until it is in excess.
   (ii) To the second half of the filtrate, add aqueous ammonia in drops and then in excess.
(c) (i) Transfer the residue into a test tube. Add about $5cm^3$ of dilute HCl and shake the mixture for some time.

(ii) Decant about $2cm^3$ of the resulting solution from (c)(i) above into a test tube. Add sodium hydroxide solution in drops and then in excess.

Science Process Skills Involved.
Basic (lower -order) process skills: **Observing, Measuring, Inferring**.
Integrated (higher-order) process skills: **Manipulation, Organizing, Data in Table, Experimenting.**
Justification for the identified skills

- Transferring **G** (a mixture of $ZnCl_2$ and iron filings) into a beaker; adding about 20cm3 of distilled water and stirring thoroughly the content in the beaker and thereafter filtering the content (**required manipulating and measuring**.
- Folding filter paper into cone shape in readiness for insertion into filtering funnel (**required manipulating**).
- Noticing the colour of the filtrate and residue (**required observation**).
- Drawing appropriate conclusions based on observation (**required inferring**).
- Noticing the reaction/action of water on the mixture (**required observation**).
- Pouring one half of the filtrate into a boiling tube and adding sodium hydroxide solution in drops until it is in excess (**required manipulation and measurement**).
- Noticing the product of the reaction between the filtrate and sodium hydroxide (in drops) (**required observation**).
- Noticing the action of excess sodium hydroxide on the product formed (**required observation**).
- Adding aqueous ammonia to the second half of the filtrate both in drops and excess (**required manipulation**).
- Noticing the product of the reaction between the filtrate and aqueous ammonia (in drops) (**required observation**)
- Noticing the action of excess aqueous ammonia on the product formed (**required observation**).
- Drawing appropriate conclusions based on observation (**required inferring**).
- Transferring the residue into a test tube, adding about $5cm^3$ of dilute HCl and shaking the mixture for some time (**required manipulating and measuring**).
- Decanting about $2cm^3$ of the resulting solution from (c)(i) above into a test tube (**required manipulating and measuring**).
- Noticing the product of the reaction between the resulting solution from (c)(i) and sodium hydroxide solution in drops (**required observation**).
- Drawing appropriate conclusions based on observation (**required inferring**).
- Presenting qualitative analysis results clearly and correctly with the aid of a qualitative analysis report Table (illustrated below+) (**Required Organizing Data in Table**).