CHEMISTRY PRACTICAL INSTRUCTIONS FOR TEACHING AND LEARNING SCIENCE PROCESS SKILLS

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Abstract

This study investigated the effects of chemistry practical instructions for teaching and learning science process skill. Prediction and interpretation skills were the skills examined in this study. The study investigated how practical instructions in chemistry can assist students possess prediction and interpretation skills. To achieve these, survey research design was employed. Two research questions and two hypotheses guided the study. Purposive and simple random sampling techniques were used to select ten (10) secondary schools from the area of study and two hundred and five(205) students from the 10 schools. The population for the study was two thousand and sixty one (2061) senior secondary school chemistry students from the area of study. Two instruments were used for data collection; Practical Chemistry Achievement Test (PCAT) and Science Process Skills Assessment Format (SPSAF) which was a checklist with four(4) points rating used to assess ability of students during practical instructions in the laboratory. The practical instructions were on volumetric analysis carried out by students in the laboratory. SPSAT was validated by experts and trial tested on six (6) senior secondary two (SS11) chemistry students outside schools in the area of study.The results were validated using split-half reliability. This gave a value of 0.66which indicated that the instrument is reliable. PCAT was adopted from SS11 chemistry practical curriculum and thus considered as standardised. PCAT was used as achievement test. A lesson note guided the skills to be acquired. The values from SPSAT and achievement test scores from PCAT were analysed using mean and standard deviation for the research questions and t-test statistical analysis for the hypotheses, the findings revealed that chemistry practical instructions affect possession of prediction skills. The results also showed that chemistry practical instructions influenced possession of interpretation skills and achievement scores of students in chemistry practical. Recommendations were made among others that practical instructions should be emphasised for acquisition of prediction and interpretation skills and achievement in chemistry.

Keyword: Science, Science Process Skills, Chemistry Practical Instructions, Prediction Skills, Interpretation

Skills.

1.1 Introduction

Science is defined as an interconnected series of concepts and conceptual activities that develop as a result of experimentation and observation (United Nation Educational, Scientific and Cultural Organization (UNESCO) in Kazeni 2005). Eshiet (1993) gave an earlier definition of Science as a body of knowledge in which human quest to understand natural phenomena. Science is knowledge gained through systematic and procedural process involving observation and experimentation (Aniodoh, 2001). It is a verifiable and testable knowledge of natural phenomena obtained through systematic observation and experimentation for the purpose of solving existing problems in nature. Teaching of science should be through hands-on and minds-on methods or approaches. In order to understand the workings of science, learners should be taught in an environment where they would develop enquiry minds. Science as conceptual deals with objects, phenomena, laws and theories whereas process of science is activity based involving observing, measuring, hypothesizing, interpreting, predicting, communicating, formulating models, controlling variables and defining operationally. These culminate what is referred to as science process skills. These are cognitive and psychomotor skills which scientists employ to identify problems, to inquire objectively, to gather data and transform the data, to make interpretation and communicate effectively (Okoli, 2006). Myer, (2006) noted that science process skills are desirable skills that scientists use in carrying out activities in science. The absence of science process skills makes practical activities in chemistry very difficult and completely impossible. Effective conduct of practical brings about acquisition of skills through "hands-on and minds-on" activities that can change an individual into a scientist. Students are more likely to learn more if they undertake practical activities that would de- emphasize rote learning, and memorization of scientific concepts and principles. The American Association of Science stated that process skills are divided into two categories based on their operational difficulties; basic and integrated skills. Basic skills are less difficult than integrated skills. Basic skills are: observation, measurement, classification, prediction, communication and inference. While integrated skills are more complex and their operational levels are more difficult. They are; controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting and formulating models.

1.2 Importance of chemistry practical instructions

Turner (2008) stated that science teaching should be such that will inculcate desirable and transferable skills which includes the ability to formulate and conduct experiments, evaluate empirical evidence, appreciate qualitative argument, carry out inductive generalization and engage in critical thinking and concise interpretation. Science curriculum should be stimulating and teachers should use instructions that would enhance active involvement of students in the learning process, develop motivation and ability to work and think independently, develop ability to recall science information and develop ability to communicate effectively and selectively. Therefore,

teachers' instructions should be aimed at fostering and developing an individual who can operate and fit adequately into the environment he finds himself. Nzewi (2008) suggested that practical activities can be regarded as strategies that could be used to make the task of teachers' instructions more real to students. Practical activities engage students in hand-on and minds-on activities using variety of instructional lessons. Chemistry is the science that deals with the properties, composition, and structure of substances (elements and compounds) in nature (https://www.britannica.com). In order to verify the properties, composition and structures of elements and compounds, there is need for practical exercise. The absence of practical in chemistry classes leaves the learners with no option than memorization of chemistry concepts (Achimugu, 2012). Chemistry practical instructions in secondary school is very important because it dispels doubt and makes abstract concepts to be real. Chemistry practical instructions is teaching chemistry in an inquiry manner in the laboratory. Chemistry practical forms 40% of the total scores in the West African Examination Council (WAEC) in chemistry result. Chemistry practical can be successful when students acquire process skills. Despite the importance of these skills, very little attention is paid to process skills in chemistry during practical instructions (Achimugu, 2012). Achimugu (2012) asserted that, chemistry teaching in secondary school is mainly done theoretically without involvement of practical classes due to absence of laboratories, lack of qualified teachers, miss- handling of equipment in the laboratory, inadequately in determining the end-point of titration, students being unfamiliar with colour or odour and identification of times of particular experiment. All these may be due to lack of practice or inefficient teaching and learning of process skills. Achimugu (1997) and Nwokorie(2008) had earlier observed that poor performance in chemistry practical can be traced to inability to take learners through practical session in the laboratory. Akpan (1999) emphasised the importance of practical activities and the absence of which will result in abstract teaching, poor performance in chemistry especially in quantitative analysis for which most skills are learnt. For chemistry practical to be effective, the teacher and learners must ensure that they follow the rules of conducting practical as outlined by the instructor. The instructor (teacher) on his/her part should follow the instruction for conducting practical as stipulated by the chemistry practical curriculum. If practical classes are properly conducted they will promote critical thinking skills, self-reliant, ability to sought for information by themselves not relying on the teachers, ability to observe, measure accurately, predict the outcome of an experiment, communicate effectively, formulate hypothesis, interpret the results of the experiment, analyse results, draw conclusions and so on. These are the activities of scientists (science process skills). Nwagbo and Chukelu (2011) noted that acquisition of science process skills is fundamental to science inquiry and development of intellectual skills and attitude needed to learn concepts and principles of science. Anugwo andAsogwa (2015) observed that practical activities in the laboratory bring about development and growth of science process skills. They emphasized that utilisation of science process skills in chemistry in secondary school is an important way where knowledge can be transferred from one aspect of life to another. Nevertheless, acquisition of science process skills goes beyond ability to perform experiment. It involves a total transformation of an individual to behave and act like a scientist. Therefore building of these skills by the learners is fundamental to the study and practice of science. The teacher should therefore adopt specific instructions relevant

to the teaching and learning of science process skills. This is possible if there is a drift from lecture method to move stimulating method like practical instruction. Skills acquired in the course of practical instructions. Skills acquired in the course of practical instructions cannot be easily forgotten (Akinbolola and Afolabi 2010). The absence of practical instructions gives rise to abstraction and memorisation of chemistry concepts. Chemistry can only be made interesting and real if concepts are thought using practical instructions. Ibe and Nwosu (2003) observed that science process skills have capabilities for enabling learners to answer questions and solve problems even at odd periods and difficult circumstances. Teachers should work towards giving instructions that would fortify learners with necessary skills to look and search for information rather than transferring information to learners. The National Policy on Education (NPE) (2013) outlined the overriding objectives of science teaching to include: "to satisfy curiosity in the individual, enhance and build in the learner positive attributes and attitudes towards science subjects". Objectives of the lesson cannot be achieved when chemistry is taught using lecture or expository method. Chemistry is a fundamental science subject that deals with the study ofelements and their compositionsand its teaching usually is practical oriented.

Njoku (1999) stated that West African Examination Council (WAEC) uses practical test /examination to assess students' acquisition of various chemistry practical skills. Ajagun (2006) noted that in Nigeria the trend of academic performance in chemistry was due to the fact that students did not represent the concepts well while they are undertaking practical exercises. Njoku (2007) stated that most teachers did not teach chemistry in other to bring out the desired skills. Chemistry is rather taught using expository or lecture method. It is pertinent to note that wrong way of teaching chemistry extends not only to practical but also to the teaching of all aspects and acquisition of desired skills. Anugwo and Asogwa (2015) indicated that learners achieved poorly in secondary school science subjects especially chemistry due to wrong methods of teaching. This was confirmed by Chief examiners' reports of 2010 to 2020 which stated that poor performance in practical work, lack of knowledge to use the laboratory, poor or wrong inference, and writing of wrong units and omission of units are characterised by constant failure of learners in West African Examination Council (WAEC). Again Igwe and Bayim (2019) discovered a significant relationship between measurement and observation skills and achievement of students in chemistry practical. Other skills that are also essential for achievement in Senior Secondary chemistry are prediction and interpretation process skills.

1.3 Concept of prediction skill

Prediction skill is basic and fundamental skill that requires learners to guess the outcome of an experiment before it is conducted. Prediction is based on students' prior knowledge. This skill is needed for effective conduct of chemistry practical and achievement in chemistry. Prediction skills involve stating the outcome of future event or experiment based on a pattern of previous evidence (elsagherscience. weebly.com/predicting.html). Example, predicting the colour change of a base when an indicator is added during volumetric analysis. Making predictions is making education guesses about the outcomes of future events. Rezba (1999) stated that the ability to make predictions about future events allow instructors and learners to successfully interact with the

environment around them. Prediction is based on both good observation and inference. It is also based on what is observed and past experiences of the learners. Prediction involves the mental models that learners have built up from those experiences. Predictions are not just guesses, there are based on inferences or hypotheses about events that had occurred. If the prediction turns out to be correct, then there is greater confidence in the inference and hypothesis. Prediction skill is closely related to other process skills like observing, inferring and classifying. A good prediction would require the use of all senses to observe what you are predicting (http://elsagherscience.weebly.com/predicting.html).

1.4 Concept of interpretation skill

Interpretation skill is a higher ordered process skill. It involves organizing data and drawing conclusions from it (https://narst.org/research.matters/). Interpretation skill requires learners to give meaning to the outcome of the experiment. For instance, recording data from an experiment conducted on acid/base titration and making conclusion based on the outcome of the experiment (https://narst.org/research.matters/). Thus successful interpretation is one that gives accurate meaning of a message without omissions, additions or embellishment by the interpreter (Veverka,2013). The interpreter must use special equipment and follow accepted professional rules/practices such as setting aside personal opinion and maintaining the confidentiality of information he is giving.

Interpretation skills are used to determine the precise meaning and significance of message or signal, whether it is a gesture, sign, set of data, written or spoken words, diagram, icon, chart or graph. Correct interpretation depends on understanding the message in its context and in terms of who sent it and for what purpose. Interpretation includes clarifying what something or someone means, grouping or categorizing information and determining the significance of a message. Interpreting skills are used to get precise meaning and significance of a meaning of a message, signals, set of data, gestures, diagrams, written or spoken words, icons, graphic or charts about things. Correct interpretation depends on giving appropriate and correct meaning to data, words, signals, responses or meanings.

In 2013, the California Academic Press confirmed that analytical and interpretative skills are used to closely examine ideas, identify assumptions, and make constructive reasons and claims, to gather detailed information from charts, graphs, diagrams, pictures, experiments and so on in order to solve scientific problems. These are the ideas of the scientists in other to establish relationship with the environment and proffer solutions to problems. In Chemistry practical classroom, students need to possess interpretation skill in order to analyze and interpret data so that results will be meaningful and acceptable. Without interpretation skill, results cannot be analyzed nor interpreted and the results of an experiment cannot be reported. This study sets out to investigate if chemistry practical instructions result in possession of prediction and interpretation skills for achievement ofchemistry in Senior Secondary Certificate Examination.

1.5 Statement of problem

Practical work is very essential as it enables students apply their knowledge and understanding more readily. Students remember activities they have performed more readily and this reduces memorization. Students who simply memorize and recall facts find it difficult to apply their knowledge to unfamiliar context. The use of practical for chemistry instructions helps students to develop science process skills. This is why practical is compulsory in West African Examination Council Chemistry Examination and other examining bodies of the sort and forms 40% of the total scores in chemistry practical in Senior Secondary Schools Certificate Examination. A pass or fail in Practical Chemistry determines the final grade in Senior Secondary Chemistry Examination. West African Examination Council (WAEC) Chief Examiner Reports (2015 to 2020) showed that poor performance in Chemistry is largely due to poor performance in practical work, lack of knowledge to use the laboratory, inability to observe colour change, poor and wrong inferences, writing of wrong units and omission of unit to non-adherence to instructions. Most of these activities hinged on skills of observation, measurement, prediction and interpretation. Most often teachers do not carry out practical instructions in chemistry. They teach in abstraction and cause students to memorize the content thus resulting in poor performance in chemistry in internal and external examination. Little work had been done on prediction and interpretation skills which are also very important in chemistry practical achievement. For this reason, this work was carried out to investigate how chemistry practical instructions can foster possession of prediction and interpretation skills in Senior Secondary Schools in Cross River State.

1.6 Purpose of the study

The purpose of the study is to find out if chemistry practical instructions is used for teaching andlearning science process skills. Specifically the study will:

(1) Investigate the extent to which students acquire prediction skills during chemistry practical instructions and their achievement in chemistry.

(2) Determine the level of possession of interpretation skills and students achievement duringpractical instructions.

1.7 Research Questions

- To what extent do practical instructions influence students' possession of predictionskills and achievement in chemistry practical?
- How do practical instructions affect possession of interpretation skills and students' achievement in chemistry practical?

1.8 Hypotheses

- Practical instructions have no significant effect on students' possession of predictionskills and achievement in chemistry practical.
- There is no significant influence of practical instructions on possession ofinterpretation skill and achievement scores of students in chemistry practical.

1.9 Significance of the study

- The study would help students acquire desired process skills to increase chemistry performance.
- The findings would be important to curriculum planners who would include desirablescience process skills in practical instructions.
- The findings would help chemistry teachers appreciate process skills that are relevantand need to be emphasized in the course of chemistry practical instructions.
- The study would assist teachers to teach science process skills using chemistrypractical instructions.

2.1 Method

This study employed a survey design. The design is relevant and appropriate because researchers observed and took records of prediction and interpretation skills exhibited by students in the course of chemistry practical instructions. The survey design is aimed at collecting data from the sample(students) as they carry out volumetric analysis in order to make generalization to the population. The study was carried out in Calabar Education Zone of Cross River State. The education zone cuts across seven Local Government Areas of Cross River State- Biase, Akamkpa, Odukpani , Calabar South, Calabar Muncipality, Akpabuyo, and Bakassi Local Government Areas. The population of the study comprised all Senior Secondary Chemistry Students in senior secondary two (SSII) in the area of study. The population was made up of two thousand and sixty one (2061) students (department of statistics). The sample was made up of two hundred and five (205)students drawn from ten (10) schools across the education zone of the State selected by simple random sampling with replacement. Criterion reference sample was used to select ten schools in the area of study. Some of the criteria used were: schools with well-furnished laboratories and schools with qualified teachers to teach chemistry. Two instruments were used for data collections-Science Process Skills Assessment Format (SPSAF) and Practical Chemistry Achievement Test (PCAT). Science Process Skills Achievement Format (SPSAF) was a checklist with thirteen (13) items rated-Very high ability (4), high ability (3), low ability (2)and very low ability

(1)points(Appendix 1). The researchers rated the skills as the students undertook the practical exercise in the laboratory on the spot. PCAT was an achievement test with practical instructions adopted from Senior Secondary two (SSII) chemistry practical curriculums. PCAT was divided into two parts: The first part provided the bio- data of the students while the second section carries the practical instructions on how to carry out practical exercise. PCAT was scored over 100% (Appendix 11). A lesson note guided the behavioural objectives that would be achieved as well as activities that were required for a successful practical session. SPSAF was validated by one expert in test and measurement and one expert in science he core education from the departments of education management and science education in the Cross River University of Technology Calabar respectively. The instrument was first face validated by the experts. The items that did not show relevance skills were dropped or reframed.13 items were finally arrived at representing the core activities that are required for acquiring prediction and interpretation skills. These were trial tested on six (6) senior secondary two (SS11) chemistry students outside the schools in the area of study. Six (6) Research Assistants were trained on how to assess the skills on the spot. The six students were assessed by research assistants as they carry out the practical exercise.

The data obtained was used to compute the reliability of the instrument using split-half reliability. This yielded the reliability of 0.66 which indicated that the instrument was reliable. The practical exercise was carried out by students in groups of five. The laboratory set up was that of volumetric analysis as recommended by SS11 chemistry curriculum. Each student worked independently during the practical session. The researchers with the help of the six trained research assistants scored the students on the spot on the possession of prediction and interpretation skills using SPSAF. The practical exercise lasted for one hour for each group. The entire exercise lasted for eight weeks.

Results

The results of the study are presented in tables:

Research Question 1:

To what extent do practical instructions influence students' possession of prediction skills andachievement in chemistry practical?

Table 1:The results of mean and standard deviation values of prediction skills and students'achievement in chemistry practical.

1. Variables	2. N	3.	4. X	5. SD	6.
7. Prediction	8. 205	9.	10. 24.86	11. 19.00	12.

13. Achievement	14. 205	15.	16. 106.84	17. 18.00	18.

The result presented in Table 1 shows the mean value of prediction of 24.86 as against all increasemean value of achievement of 106.84 in chemistry practical.
The result implies that there is high effect of possession of prediction skills on students'achievement in chemistry practical.
Research Question 2:
How do practical instructions affect students' possession of Interpretation skills and achievementin chemistry practical?

Table 2: The result of mean and standard deviation values of interpretation skill and students'achievement in chemistry practical

19. Variable	20. N	21. X	22. SD
23. Interpretation	24. 205	25. 54.30	26. 6.08
27. Achievement	28. 205	29. 106.84	30. 18.00

The result presented in Table 2 revealed the mean value of interpretation skill of 54.30 as againsthigh value of students' achievement of 106.84 in chemistry practical.

Hypothesis 1:
Practical instructions have no significant effect on students' possession of prediction skills andachievement in chemistry practical.

Table 3:Summary data of independent t-test of the prediction skill on students' achievement inchemistry practical

31. Variable	32. N	33. X	34. SD	35. Df	36. T	37. Sig *
38. Prediction	39. 205	40. .4.86	41. 19.00	42. 19.00	43.	44.

45. Achievement	46. 205	47. 106.84	48. 18.00	49. 203	50. .98	51. .33

P>0.05 alpha level, df =203

In Table 3, since the calculated t-value of .96 which is greater than the critical t-value of .39 at .05 level of significance and 203 degree of freedom for two tailed test. It follows that the null hypothesis of no significance influence is therefore rejected, but the alternate hypothesis is retain.

Hypothesis 2: There is no significant influence of practical instructions on possession of interpretation skill and achievement scores of students' in chemistry practical.

Table 4: Summary data of independent t-test of interpretation skills on students' achievement in chemistry practical

52. Variable	53. N	54. X	55. SD	56. df	57. T	58. Sig *
59. Prediction	60. 205	61. 54.30	62. 6.08	63. 203	64. .79	65. .33
66. Achievement	67. 205	68. 106.84	69. 18.00	70. 203	71. .98	72. .33

P>0.05 alpha level, df =203

The result of Table 4 revealed that the calculated t-test value of .97 is greater than the critical value of .33 at 0.05 level of significant with 203 degree of freedom. With this result, the null hypothesis of no significant influence of interpretation skills on students' achievement in chemistry practical instruction is rejected. This implies that there is significance influence.

2.2 Discussion of findings

Discussion of hypothesis 1:Practical instructions have no significant effect on students' possession of prediction skills and achievement in chemistry practical.

Items 1-5 of SPSAF were used to analysed the possession of prediction skill and achievement in chemistry practical instructions. When t-test was used to test hypothesis 1 which stated that practical instructions have no significant effect on students' possession of prediction skills and achievement in chemistry practical was significant, since the calculated t-value of .96 is greater than the critical t-value of .39 at .05 level of significance and 203 degree of freedom for two tailed test. It follows that there is significant influence. The null hypothesis of no significance influence istherefore rejected, but the alternate hypothesis is retain.

The findings is in line with the studies of Akinbolola and Afolabi (2010), Anugwo and Asogwa (2015) in their separate studies observed that practical activities in the laboratory bring about development

and growth of science process skills which include prediction and interpretation skills. It is a requirement that a pass or fail in chemistry practical determines the final grade in Senior Secondary School Chemistry Examination. West African Examination Council (WAEC) Chief Examiner Reports spanning over a decade (2004, 2005, 2008, 2009, 2010, 2011, 2012, 2014 and 2015) showed that poor performance in chemistry is largely due to poor performance in practical instructions, lack of knowledge to use the laboratory, poor and wrong inferences, writing of wrong units and omission of unit to non-adherence to instructions. Most of these activities hinged on skills of prediction and interpretation which are greatly acquired during chemistry practical instructions.

Discussion of hypothesis 2:There is no significant influence of practical instruction and possession of interpretation skill and achievement scores of students in chemistry practical.

Items 6-13 in SPSAF were used to analysed the possession of interpretation skill and achievement during chemistry instructions. The results as showed in Table 4 revealed that the calculated t-test value of .97 is greater than the critical value of .33 at 0.05 level of significant with 203 degree of freedom. With this result, the null hypothesis of no significant influence of interpretation skills on students' achievement in chemistry practical instruction is rejected. Thus the null hypothesis of no significant was rejected and the alternate one retain. The finding is in line with The California Academic Press 2013 affirmation that in chemistry practical classroom, students need to possess interpretation skill in order to analyse and interpret data so that results will be meaningful and acceptable. Without interpretation skill, results cannot be analysed nor interpreted and the results ofan experiment cannot be reported thus poor achievement in chemistry practical.

2,3 Recommendations

The recommendations made from the results of the study are:

- Chemistry teachers should emphasize practical instructions that will develop scienceprocess skills.
- Students should be taught using inquiry method of teaching in order to acquireprediction and interpretation skill.
- Chemistry practical instructions should be emphasised in senior secondary classes.
- Practical instructions should be conducted frequently during chemistry teaching.

2,4 Conclusion

The purpose of the study was to investigate if practical instructions are used for teaching and

learning science process skills with specific emphasis on prediction and interpretation skills.

The findings revealed that chemistry practical instructions have effects on students' possession of prediction and achievement in chemistry practical.

The findings also showed that chemistry practical instruction influence possession of interpretation skill and achievement scores of students in chemistry practical.

Based on the findings, recommendations were made to assist teachers to effectively deliver practical instructions in chemistry that would assist students to acquire science process skills especially prediction and interpretation skills in senior secondary schools in Cross River State.

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