Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 9 ~ Issue 1 (2023) pp: 96-100
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Evaluating Students' Ability in the Determination of Accuracy and Precision in Some Aspects of Chemistry Practicals

[*a]Ahmad Y. M., [b]Ibrahim H. A.,[a]Mukhtar N. A. and [a]Khalifa M. H.
*[*a]Department of Chemistry Sa'adatu Rimi College of Education, Kumbotso, Kano State, P.M.B. 3218, Nigeria.*
[b.]Department of Biology Sa'adatu Rimi College of Education, Kumbotso, Kano State, P.M.B. 3218, Nigeria.
[*]E-mail: yusufmusa900@yahoo.com

ABSTRACT: *This research work is aimed at evaluating students' ability in the determination of accuracy and precision in some aspect of practical chemistry. An experimental research method was applied to school students which were grouped into 'A' and 'B' respectively. The students were trained on the basic practical aspects, i.e measurement of the weight of a given samples and measuring the volume of acid from a burette prior to the administration of students performance test. The three distinct weights of calcium carbonate ($CaCO_3$) viz: 10g, 20g and 30g were required to be measured by the students in the practical performance test. The result obtained from group 'A' students shows that percentage error of measurement when compared with the standard value was 0.00%, 2.50% and 0.00% respectively, this is highly accurate for the two measurements and the middle value reflect a little error. The percentage error calculated from group 'B' gives 50.00%, -2.50% and 0.00%, this results shows that there was no accuracy in the first two measurements but last one was accurate. With regards to precision researcher's findings revealed that group 'B' measurement shows better precision over 'A' in the reproducibility of the volume of acid measured. Based on these results it is recommended that government, school authority and other stakeholders should provide adequate materials and relevant resources to enable teachers facilitate effective teaching and learning process.*

Key words: *Chemistry, measurement, accuracy, precision and practical knowledge.*

R*eceived 11 Jan., 2022;* ***R****evised 25 Jan., 2023;* ***A****ccepted 27 Jan., 2023* *© The author(s) 2023.*
P*ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

Chemistry is a central science that cuts across all the sciences and its importance can never be over emphasized. Chemistry is fundamental in the world of industrialization. The main aim of science education and educational training policy is to provide quality education and to find out the best way to improve students' achievement in science [1].Today, the world is seen as global village meanwhile, this perception of globalization is not connected with industrialization in which chemistry is central. Chemistry has multiple benefits for national development. It plays fundamental roles in food production, clothing, housing, medicine, transportation, etc.

Various studies from last decades have addressed aspects that we believe are relevant to the preset study. In those perspective, the focus is on inquiry [2];[3]; [4]; [5]; [6];[7], practical work [8]; [9], hands-on practices [10], and science practices [11]. Four reviews on laboratory work were also found; however, only two partly overlapping reviews looked at secondary school science [12]; [13], while the third reviewed tertiary-level chemistry education [14], and the fourth reviewed practitioner articles [15]. In the following sections, we summarise these reviews in which Hofstein and Lunetta [12] have precedingly concluded that laboratory investigations offer important opportunities for students to connect science concepts and theories with observations of phenomena and systems. In a meta-analysis of the effect of inquiry teaching,.[4] analysed 37 studies from 22 articles, and found a moderate effect size in favour of inquiry teaching. Similarly, in a meta-analysis of 13 studies on the effectiveness of inquiry-based learning in science,[5] showed a tendency towards improved learning outcomes as a result of inquiry-based learning in comparison to traditional approaches. The effects of inquiry-based learning were more prominent in secondary than in primary education, and the largest effect size was seen when a preparation unit prior to the inquiry-based lesson was included[5].

[16] observed that practical chemistry at senior secondary certificate level aimed at training students in the scientific techniques of recording, observation accurately and drawing reasonable inferences. Students of practical chemistry are expected to conduct practical aspect of chemistry using standard procedure. Chemistry as a branch of science it's the study of matter, structure, properties, composition and its transformation. The study of chemistry enable learners to acquire appropriate skills, abilities and competencies that would enable them contribute to the development of society. Chemistry is pivotal to the transformation and development of nations because it has continued to play an increasingly important role in the production of many technologies from life-saving pharmaceuticals to computers and other information technologies[17].

Inquiry, also a frequently used term in the field, can briefly be described as a student- led investigation that begins with a question[18]. Hence, inquiry is a rather non-specific term that can be used in many ways in relation to strategies that emphasize the student's role in the learning process. In response to this rather vague understanding of what doing science is all about, the concept of 'science practices' was introduced as a term in the 21st-century science education standards by the National Research Council [19]. According to[18], science practices describe a broader, but articulated, understanding of doing science in comparison to inquiry: 'The idea involves students going beyond experiencing inquiry by interpreting and evaluating data as evidence to developing arguments, explanations, and models. This definition certainly specifies the science in doing science, but also embraces aspects of how scientific knowledge is developed that are not necessarily dealt with in practical laboratory work. Therefore, we consider laboratory work to be the most appropriate concept to represent the defined phenomenon of interest in this study. As argued by[14] 'laboratory education became a separate and distinct component of education, with the emphasis intended to teach students about how to "do science". It is, nevertheless, important to point out that we include all identified studies covering our definition, regardless of the terminology used.

Chemistry is essentially a laboratory activity-oriented subject. No course in chemistry can be considered as complete without including practical work in it. Laboratory activity here is used to describe the practical activities which undertake using chemicals and equipment in a chemistry laboratory. Research have shown that certain factors like teachers' attitude, lack of funds and curriculum innovation affects students' performance[20]. In a review of laboratory work in tertiary chemistry education[14] emphasised the importance of preparing students beforehand. They separated supportive and procedural information and claimed that the former is needed to give students an understanding of the whole laboratory task in general terms – a kind of theoretical framework in which the laboratory experiment operates. Procedural information, on the other hand, related to the specific details necessary for operating in the laboratory, i.e., the skills needed to handle certain equipment[14]. These findings amplify the importance of the planning phase, and as shown by [8], this aspect seems difficult for teachers to accomplish, making it key for further investigation.

Measurement refers to the quantification results obtained through measurement with available references to determine whether a product is acceptable or not. When measuring a lengthusing a ruler it is possible to make some sort of decision based on the value, such as "The measurement is a little too long/short." This determination is another way of saying, "Based on the value obtained using a ruler (measurement), it has been determined that the value is slightly longer (or shorter) than the length of interest." Although there is often no need to use these definitions separately.

Accuracy refers to the level of agreement between the actual measurement and the absolute measurement. In the chemistry, the term 'accuracy' is used in relation to a chemical measurement. The International Vocabulary of Basic and General Term in Metrology (VIM) define accuracy of measurement as "Closeness of the agreement between the resultsof a measurement a true value." The VIM remains us that value that would be obtained by a perfect measurement. Since there is no perfect measurement in analytical chemistry, we can never know the true of value. Our inability to perform perfect measurements is thereby determined true a value does not mean that we have to give up the concept of accuracy. However, we must add the reality of error to our understanding. The term 'accuracy', mean the degree of compliance with the standard measurement, i.e. to which extent the actual measurement is close to the standard one, i.e. bulls-eye. It measures the correctness of the result at the same time by comparing it to the absolute value.

Precision represents the uniformity or repeatability in measurements. It is the degree of excellence, in the performance of an operation or the techniques used to obtain the results. It measures the extent to which the results are close to each other. i.e. when the measurement are clustered together. Therefore, the higher the level of precision the less is the variation between measurement, for instance: Precision is when the same spot is hit, again and again, which not necessarily the correct spot.

Precision is a description of a level of measurement that yields consistent results when repeated. It is associated with the concept of "random error", a form of observational error that leads to measurable values being inconsistent when repeated .The term precision is used in describing the agreement of a set of results among themselves. Precision is usually expressed in terms of the deviation of a set of results from the arithmetic mean of the set (mean and standard deviation to be discussed later in this section). The student of analytical chemistry is taughtcorrectly that good precision does not mean good accuracy. However, it sounds reasonable to assume otherwise.

II. METHODOLOGY

This study was carried out among students of SS II Staff Secondary School Sa'adatu Rimi College of Education Kumbotso, located along Zaria Road, Kano. The population of the students used was 20 students which were grouped into 'A' and 'B' for convenience and to also minimize the practical materials and apparatus. These groups of students were instructed to weigh a sample of Calcium carbonate ($CaCO_3$) in three different quantities of 10g, 20g, and 30g respectively using a beam-balance as an instrument the results obtained were treated using a suitable formula and their respective percentage errors were calculated. The precision in the measurement of acid volume was determined by the students by measuring the burette readings of three different experiments and finally the values obtained were compared in order to determine precision (reproducibility of values in a repeated experiment)and average titre was also calculated.

III. RESULTS

The following results were obtained and presented in tabular forms, after weight measurement percentage error was calculated for the values and compared with standard value in order to evaluate the accuracy.

$$percentage error = \frac{\text{Obtained result} - \text{expected result}}{\text{Expected result}} x\ 100$$

Table 1: Percentage error obtained from the $CaCO_3$ Weighing by Group 'A' Students

S/N	Measured weight of $CaCO_3$ (grams)	Percentage Error (%)
1.	10.00	0.00
2.	20.50	2.50
3.	30.00	0.00

The above formula was used to obtain the percentage error both for the two groups (A and B), from the table above the students obtained first weight as exactly 10g as such the calculated percentage error was found to be (0.00%) this gives highly accurate result, the second weighing was found to be 20.50g thus gives a percentage error of 2.50% when compared with the standard or expected value therefore this measurement was not accurate. However, for the third weighing exactly 30g of $CaCO_3$ was obtained hence zero (0.00%) relative error when compared with expected/standard value, a highly accurate result was also obtained.

Table 2: Percentage error obtained from the $CaCO_3$ Weighing by Group 'B' Students

S/N	Measured weight of $CaCO_3$ (grams)	Percentage Error (%)
1.	10.00	-50.00
2.	19.50	-2.50
3.	30.00	0.00

From the table above its observed that the calculated percentage error for the first weighing of $CaCO_3$ was found to be (-50.00%) thus low accurate result was obtained. For the second measurement (-2.50%) relative percentage error was calculated this also gives low accurate measurement was done by the students when compared with the standard value. However, for the third measurement zero (0.00%) relative percent error was calculated by the students hence accurate result was obtained among the three different measurement.

Table 3: Determination of Precision by Group "A" Students

S/No	Burette reading (cm^3)	I	II	III
1	Final	25.00	24.50	24.20
2	Initial	0.00	0.00	0.00
Volume of the acid used		25.00	24.50	24.20

The average titre value $= \frac{24.50+24.20}{2}$ = 24.40 cm^3

Table 3 shows that, 24.50 and 24.20 are the two concordant values and the different is more than 0.2 therefore, the average obtained has a wide difference with the selected values. The accuracy of 2nd and 3rd titration is what gives the precision of **24.40cm^3**with a difference of 0.3 as indicated in the study, the findings show that, Group A does not determine the precision accurately since the difference obtained is above 0.2 i.e. is not in accordance with [21] practical chemistry.

Table 4: Determination of Precision by Group 'B' students.

S/No	Burette reading (cm^3)	I	II	III
1	Final	21.60	43.10	21.50
2	Initial	0.00	21.60	0.00
Volume of the acid used		21.60	21.50	21.50

The average titre value $= \frac{21.60+21.50+21.50}{3}$= 21.53$cm^3$

The above table shows that, 21.60, 21.50 are the concordant value, since the difference is not more than 0.2 as stated by[21]a practical chemistry. Therefore, the average, does not have a wide difference with the selected values. The accuracy of 1st, 2nd and 3rd titration is what gives the precision of 21.53cm^3 with a difference of 0.1 as obtained in the study. The findings show that Group B have the ability to determine the precision, since the difference obtained is less than 0.1. That is very good precision is obtained.
The findings of the two Groups indicated that, the students from the selected Groups have the ability to conduct measurement in practical class in the selected of study.

IV. DISCUSSION

The main aim of this study was to evaluatestudent ability in determination of accuracy and precision in practical classes. The study collected data on three (3) major Objectives: to find out the students' perception of practical knowledge, to investigate student's ability in measurement at practical class and to find out the students' ability of accuracy and precision in measurement

From the data presented in table 1and 2 shows that, the students had the ability in determination of accuracy since most of their measurement reflect closeness to known or standard value. WAEC uses practical examination to assess students' acquisition of various chemistry practical skills. In these tests, candidates are required to carry out certain chemistry practical activities following some given instructions.

The scores of the candidates obtained through the marking of their practical reports indirectly indicates the level of practical skills they could demonstrate during the practical examination.

Table 3 and 4 shows that, the students had the ability in the determination of precision at practical class this is because precision reflects how reproducible measurement are even if they are far from the accepted value. This is also in line with the work of Omiko [22] which aimed to investigate the roles of the laboratory in students achievement in Chemistry in the secondary School. The findings of this research also indicated that the students have interest in practical knowledge base on their participation.

V. RECOMMENDATION

Based on this research finding the following recommendations were made:

i. Government, School Authorities as well as relevant stakeholders should provide adequate required practical materials in order to facilitate effective teaching and learning practical aspects in chemistry classes.

ii. Government and other agencies should make funds available for the procurement of practical materials in the schools.

iii. Routine seminars/workshops on utilization of laboratory equipment and other practical training should be organized for science teachers for capacity building.

REFERENCES

[1]. Lucas, A. C., (2013). Provision of quality Educational Training Policy: Way forward to improve students' achievement in science. National policy on Education, 5th Edition.
[2]. Chin, C., & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning science. Studies in Science Education, 44(1), 1–39. https://doi.org/10.1080/03057260701828101
[3]. Dobber, M., Zwart, R., Tanis, M., & van Oers, B. (2017). Literature review: The role of the teacher in inquiry-based education. Educational Research Review, 22, 194–214. https://doi.org/10.1016/j. edurev.2017.09.002
[4]. Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. Review of Educational Research, 82(3), 300–329. https://doi.org/10.3102/0034654312457206
[5]. Heindl, M. (2019). Inquiry-based learning and the pre-requisite for its use in science at school: A meta-analysis. Journal of Pedagogical Research, 3(2), 52–61. https://doi.org/10.33902/JPR.2019254160
[6]. Herranen, J., & Aksela, M. (2019). Student-question-based inquiry in science education. Studies in Science Education, 55(1), 1–36. https://doi.org/10.1080/03057267.2019.1658059
[7]. Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. Review of Educational Research, 86(3), 681–718. https://doi.org/10.3102/0034654315627366
[8]. Akuma, F. V., & Callaghan, R. (2019). A systematic review characterizing and clarifying intrinsic teaching challenges linked to inquiry-based practical work. Journal of Research in Science Teaching, 56(5), 619–648. https://doi.org/10.1002/tea.21516
[9]. Dillon, J. (2008). A review of the research on practical work in school science. King's College.
[10]. Caglak, S. (2017). Does hands-on science practices make an impact on achievement in science? A meta-analysis. Journal of Education in Science Environment and Health, 3(1), 69–87. https://doi.org/ 10.21891/jeseh.275708
[11]. Halawa, S., Hsu, Y.-S., Zhang, W.-X., Kuo, Y.-R., & Wu, J.-Y. (2020). Features and trends of teaching strategies for scientific practices from a review of 2008–2017 articles. International Journal of Science Education, 42(7), 1183–1206. https://doi.org/10.1080/09500693.2020.1752415
[12]. Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. Science Education, 88(1), 28–54. https://doi.org/10.1002/sce.10106
[13]. Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Teaching and learning in the school science laboratory. An analysis of research, theory, and practice. In S. K. A. In & N. G. Lederman (Eds.), Handbook of research on science education (pp. 393–431). Erlbaum.
[14]. Agustian, H., & Seery, M. (2017). Reasserting the role of pre-laboratory activities in university chemistry laboratories: A proposed framework for their design. Chemistry Education Research and Practice, 18(4), 518–532https://doi.org/10.1039/C7RP00140A
[15]. Puttick, G., Drayton, B., & Cohen, E. (2015). A study of the literature on lab-based instruction in biology. The American Biology Teacher, 77(1), 12–18. https://doi.org/10.1525/abt.2015.77.1.3
[16]. Fasakin, A. O. (2003) Suggestion for improving candidate performance in practicalChemistry in oluruntage (ed) strategies for enhancing the teaching and Learning science, technology and mathematics for learners. Gain Vol. II Ikare, Calvary way publishers.
[17]. Okerie, E.U (2018) Introduction to special methods chemistry, Lagos spring field Books.
[18]. Crawford, B. (2014). From inquiry to scientific practices in the science classroom. In N. G. Lederman & S. K. Abell (Eds.), Handbook of research on science education (Vol. 2, pp. 515–541). Routledge.
[19]. National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. The National Academies Press. https://www.nap.edu/read/13165/chapter/1
[20]. Okoro, S. R. (2005): "Issues brief on Educational foundations". Encyclopedia of Educational Research, 2 August, 2005.
[21]. Ojokuku G. (2019) A practical chemistry for schools and colleges. MacChin Multimedia Designers, Samaru, Kaduna State, Nigeria.
[22]. Omiko J. O. (2015). Quality Assurance In Teaching and Learning in Tertiary Institutions in Nigeria.