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Evaluation of chemistry practical in public senior schools using ATO Stake's model of evaluation

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ABSTRACT

This study evaluated chemistry practical (CP) in public senior secondary schools using Stake's ATO model of evaluation, data were analyzed using both descriptive and inferential statistics; 60 respondents from 2 intact classes of SSS II randomly selected provided the data. Teacher's Factors Scale (r = 0.82). Chemistry Practical Achievement Test (r = 0.81), Students' Learning Facilities Scale (R = 0.81), Chemistry Practical Skills Test (r = 0.83) were the instruments. The results show a lack of laboratory equipment in schools; students possess practical skills; there is a significant relationship between learning materials and students' achievement in CP ($r = .145$, $p < 0.05$); there is no significant relationship between teachers' factors and students' achievement in CP ($r = .0.83$, $p > 0.05$); there is a significant relationship between students' practical skills and students' achievement in CP ($r = -.134$, $p > 0.05$). This study establishes that practical skills and learning facilities improve students' achievement in CP, therefore, teachers should engage students in practical work, the government should equip schools with practical laboratory equipment.

Keywords: chemistry practical, teacher's factors, practical skills, students 'achievement

INTRODUCTION

Teaching chemistry practical has become the major issue in secondary schools as most schools either lack a standard laboratory or laboratory without equipment for conducting experiments. The frequency of conducting practical in schools goes a long way to determining students' achievement and their conceptual knowledge in basic chemical concepts. How frequent practical classes are conducted depends on many factors such teacher's factor, laboratory adequacy, students' attitude among others. Although students' performance in chemistry classes is influenced by several factors, however, the number of time chemistry practical is conducted, and the quality of chemistry practical is more crucial. Teaching and learning chemistry requires instilling in students' scientific processes, attitudes, skills, and concepts, all of which can be accomplished through practical exercises. Regular exposure of students to chemistry practical can assist them in drawing conclusions and making scientific observations, promoting teamwork, tolerance, mutual understanding, cooperative learning, and peaceful cohabitation among others.

Aloys et al. (2023) refers to chemistry practical as students' engagement, experience and academic performance in chemistry using hands-on practical chemistry activities. Chemistry practical allows students to interact with materials or with secondary sources of data to observe and gain an insight about the natural world. Chemistry practical is experimental works in chemistry which allow them to express themselves in a hands-on learning environment to improve their comprehension because it allows them to engage with secondary sources of information and helps them retain scientific truths. Udogu and Emendu (2017) stated that practical chemistry helps students develop scientific attitudes like objectivity, honesty, curiosity, patience, open-mindedness, etc.; it helps students understand and appreciate the spirit and methods of science like problem solving, analytical minds, and methods of science, among other things; and it helps students develop science process skills like observing, classifying, predicting, measuring, drawing, recording data, hypothesizing, etc.

The Nigerian Educational Research and Development Council (Nigerian Educational Research and Development (NERDC), 2019) highlighted the value of chemistry practical by identifying the acquisition of fundamental theoretical and practical knowledge and skills as one of the goals of teaching chemistry in senior secondary school. Taber (2023) established that practical work makes students active in the learning process rather than just passive recipients of teaching. Aloys et al. (2023) advanced that chemistry practical helps students to achieve cognitive, psychomotor, and affective objectives. Taber (2014) highlighted that constructivist perspectives are

that teachers' instructions to pupils may not be sufficient for the transfer of knowledge unless they are permitted to develop their own learning in terms of their previous knowledge and understanding. Udogu and Emendu (2017) obtained that practical activities impacted students' chemistry laboratory exercises substantially, via students' interaction with primary sources of materials in the laboratory, scientific attitude and interest of students are maintained in chemistry. Students' achievement in chemistry might be impacted by the quality of chemistry practical.

Chemistry practical achievement is the success that students record in the practical, either as a result of regular exposure to the subject or because of favorable conditions related to it. According to Attah (2014), students' success in this area might be compared to their performance in chemistry practical. This teaching aligns with Yüksel and Geban (2014), who defined academic achievement as the degree to which students meet goals set in an educational process, usually evaluated through exams to assess knowledge and skills acquired in educational courses. Students' success in practical chemistry is a result of their exposure to frequent practical work in chemistry. Achievement is a useful indicator of how successfully an intervention or plan has affected kids in terms of their learning progress. In line with Adesoji et al. (2017), students' achievement in chemistry practical could be an indicator of quality and effectiveness of hands-on activities in the laboratory which can be used to measure how well educational objectives are being attained.

However, numerous studies have shown that secondary school students' performance in chemistry practical is unimpressive, and this has been ascribed to a number of factors. According to Taber (2023), elements like the amount of time and resources allocated to laboratory work can have a big impact on students' attitudes and learning. Poor exposure to laboratory techniques and experimental procedures, inability to perform necessary tests, lack of exposure to practical work, poor knowledge of separation techniques, inability to record observations and draw logical conclusions, inaccurate burette readings, lack of fundamental concepts and principles of practical chemistry, and inability to distinguish between theoretical knowledge and practical observation were all noted in the WAEC chief examiners' reports (The West African Examination Council (WAEC), 2022). Aloys et al. (2023) highlighted that some difficulties that hinder the effective utilization of chemistry practical work include students' insufficient chemical reagents, lack of laboratory apparatus, small laboratory space, and shortage of time allocated to the practical works. Etiubon and Ufonabasi (2014) asserted that the quality of chemistry teachers are likely to have a major influence on the students' performance. It follows that students' success in chemistry is influenced by the quality of their chemistry teacher. The number of years of experience a teacher has is another element of relevance in this study. According to Ene et al. (2022), a teacher's years of experience in the classroom affect students' average academic performance. The number of years a teacher has been teaching is referred to as their years of experience. As with Etiubon and Ufonabasi (2014), a teacher's year of experience is related to their exposure to new teaching concepts, pedagogical techniques, problems, and teaching success and accomplishments.

Chemistry practical learning resources are those facilities that can help with the execution of chemistry practical in schools; these resources include teaching aids like textbooks, lab apparatus, and charts, among others. Learning materials are used to convey concepts and information to students. Learning facilities are textbook-based resources that provide teachers and students with direction (Nyachwaya & Gillaspie, 2015). According to Ibrahim (2023), these learning resources are things that the student can see, feel, and hear, and that can help the learning process be successful. He went further to establish that learning facilities are the resources that students require in order to comprehend the chemical lessons. Ibrahim (2023) highlighted how instructional materials support teaching and learning in educational development as well as students' academic achievement. He continued by demonstrating that these resources are sufficient to facilitate independent chemistry study and encourage student participation in class activities by shifting the focus of the learning environment from the teacher's center to the students' center. By implication, learning resources for practical chemistry are important components of learning activities; they have the potential to influence students' performance and practical abilities.

Chemistry practical is a hands-on activity that helps learners to have real-world experience in the laboratory, it is a core section of chemistry education. Unarguably it has a significant impact on students' achievement in this regard. There are various studies in this aspect of chemistry at secondary school level. Researchers in this field have identified various factors militating against successful teaching of chemistry practical in secondary schools, factors such as teacher's quality, teacher's experience, students' attitude, teacher's perception about chemistry syllabus etc., have been identified. However, evaluating chemistry practical with ATO Stake's model in this regard remains unexplored. It is against this background that this study evaluates chemistry practical using ATO Stake's model to evaluate chemistry practical in public senior secondary schools.

Research Gap and Objectives

Chemistry practical, a hands-on activity, can improve students' achievement and performance in chemistry, can ignite their motivation and interest, can help them to connect theory to practice, and can deepen their conceptual understanding of the subject. Studies have shown that secondary schools' teaching of chemistry practical fluctuates, though numerous scholars have pinpointed several possible reasons for this, such as insufficient facilities, broken laboratory apparatus, an unqualified chemistry instructor, poor infrastructure and student attitudes, to name a few. In spite of all these efforts, the issue persists at the secondary school level. Therefore, this study evaluated chemistry practical using ATO model by identifying learning resources and teacher's factors as parts of the main causes of the inconsistent instruction of chemistry practical in public senior secondary schools in Ibadan, Nigeria.

Table 1. Evaluation framework

Antecedents	Transactions	Outcomes
Learning Facilities Teacher's Factors	Practical Skills	Students' Achievement

Research Questions

In other to evaluate the teaching of chemistry practical in public senior secondary schools in Ibadan, Nigeria, the study answered the following questions:

RQ1 Do chemistry students have access to learning facilities?

RQ2 Do students possess relevant practical skills in chemistry?

RQ3 Is there any relationship between learning materials and students' achievement in chemistry practical?

RQ4 Is there any relationship between teacher's factors and students' achievement in chemistry practical?

RQ5 Is there any significant difference between scientific skills and students' achievement in chemistry practical?

The Conceptual Framework

Stakes' (1977) ATO model provided the evaluation framework for this study. The components of the model are Programme Antecedent, Programme Transaction and Programme Outcome, the stages in the model are:

1. Antecedent,
2. Transaction and
3. Outcome.

Table 1 presents the evaluation model for the study.

Programme antecedent

The data gathered here investigated teacher's factors (qualification of teacher, perception of teacher and teacher's years of experience) and learning facilities in chemistry practical.

Programme transaction

This aspect collected data about practical skills that chemistry students exhibit in chemistry practical.

Programme outcome

This aspect collected data on the effects of independent variables on students' achievement in chemistry practical, that is, the relationship between students' achievement in chemistry practical and the independent variables of the study.

METHODOLOGY

The study adopted ex-post facto research design from both the descriptive and the inferential statistics to generate data from science students in Public Senior Secondary School from Egbeda Local Government Area Ibadan, Nigeria. The researcher, with the assistance of chemistry teachers in the selected schools, administered the questionnaires to students in the selected schools. The respondents filled out questionnaires in their various chemistry classrooms, this took place during the normal period, and it was collected at the end of the period, this took up to a few weeks.

The study was limited to two public senior secondary schools with sixty respondents in Egbeda Local Government Area in Ibadan, Nigeria. SS II science students were selected for the study.

Research Design

In a bid to evaluate chemistry practical in public senior secondary schools in Ibadan, Nigeria, ATO model of evaluation was adopted as the evaluative model, Teacher's Factors Scale (TFS) (r = 0.82), Chemistry Practical Achievement Test (CPAT) (r = 0.81), Students' Learning Facilities Scale (SLFS) (R = 0.81), Chemistry Practical Skills Test (CPST) (r = 0.83) were developed by the researcher to generate data for the study.

Procedure for data analysis

Procedural stages involve visitation by the researcher to the schools to seek permission from the authorities and to meet with chemistry teachers in the selected schools. Thereafter, the test items were administered and retrieved from the students. The data collected were analyzed using descriptive and inferential statistical.

RESULTS AND DISCUSSION

Table 2 shows the distributions of students' responses to item on LFS are discussed below: I don't have access to school library, No 52 (35.6%), Yes 94 (64.4%) is therefore ranked highest in the Mean Score Rating and it's followed by there is no adequate provision for textbook in my school No 66 (45.2%), Yes 80 (54.8%), Chemistry textbooks are too expensive, I don't have one No 66 (45.2%), Yes 80 (54.8%), I

Table 2. Learning facilities

S\N	Access to learning facilities	No	Yes
1	I don't have access to school library	52(35.6%)	94{64.4%)
2	There is no adequate provision for students' textbook in my school	66(45.2%)	80(54.8%)
3	Chemistry textbooks are too expensive, I don't have one	66(45.2%)	80(54.8%)
4	I don't have access to school's textbook	64(43.8%)	82(56.2%)
5	I don't have chemistry practical textbook	51(34.9%)	95(65.1%)
6	Our classrooms have computers and projector	100(100%)	-
7	I don't have access to computer and internet	19(13.0%)	127(87.0%)
8	I don't have workbook for chemistry practical	49(33.6%)	97(66.4%)
9	My school does not provide textbook for us	78(53.4%)	68(46.6%)
10	I don't have access to text books?	48(32.9%)	98(67.1%)

Table 3. Chemistry students' practical skills

S/N	Practical Skill	Mean	SD	Remark
1.	Observation	2.45	1.01	Possessed to some extent
2.	Manipulation	3.14	1.45	Highly Possessed
3.	Classification	2.67	0.23	Highly Possessed
4.	Experimentation	3.32	1.24	Highly Possessed
5.	Measurement	2.43	1.00	Possessed to some extent
6.	Numeracy	1.43	1.57	Possessed to some extent
7.	Recording	1.54	0.32	Possessed to some extent
8.	Communication	2.13	1.24	Possessed to some extent
9.	Drawing	3.47	1.09	Highly Possessed
Grand Meann=2.51				

Table 4. Relationship between learning materials and students' achievement in chemistry practical

		Achievement	Learning Materials
Achievement	Pearson Correlation	1	.145
	Sig. (2-tailed)		.027
	N	60	
Learning Materials	Pearson Correlation	.145	1
	Sig.(2-tailed)	.027	
	N	60	60

*Significance at 0.05

Table 5. Relationship between teacher's factors and students' achievement in chemistry practical

		Achievement	Teacher's Factors
Achievement	Pearson Correlation	1	.083
	Sig. (2-tailed)		.030
	N	60	60
Teacher's Factors	Pearson Correlation	.083	1
	Sig.(2-tailed)	.030	
	N	60	60

*Significance at 0.05

Table 6. Relationship between practical skills and students' achievement in chemistry practical

		Achievement	Practical Skills
Achievement	Pearson Correlation	1	-.134
	Sig. (2-tailed)		.000
	N	60	60
Practical Skills	Pearson Correlation	-.134	1
	Sig.(2-tailed)	.000	
	N	60	60

*Significance at 0.05

don't have access to school textbook No 64 (43.8%), Yes 82 (56.2%), I don't have chemistry practical textbook No 51 (34.9%), Yes 95 (65.1%), our classrooms have computers and projector No 100 (100%), Yes 0 (0%), I don't have access to computer and internet No 19 (13.0%), Yes 127 (87.0%), I don't have workbook for chemistry practical No 49 (33.6%), Yes 97 (66.4%), my school does not provide textbook for us No 78 (53.4%), Yes 68 (46.6%), I don't have access to text books? No 48 (32.9%), Yes 98 (67.1%).

Table 3 presents the result of analysis of chemistry students' practical skills; the result indicates that manipulation, classification, experimentation and drawing skills are highly possessed by students while observation, measurement, numeracy, recording and communication skills are also possessed but to some extent by chemistry students.

The outcome of this study as presented in **Table 4** shows that there is a statically significant linear relationship between learning materials and students' achievement in chemistry practical ($r = .145$, $p < 0.05$). The direction of the relationship is positively correlated i.e. the two variables tend to increase together.

Table 5 shows that there is no statiscally significant linear relationship between teacher's factors and students' achievement in chemistry practical ($r = 0.83$, $p > 0.05$)

The outcome of this study as presented in **Table 6** shows that there is a statically significant linear relationship between students' practical skills and students' achievement in chemistry practical ($r = -.134$, $p > 0.05$). The direction of the relationship is negatively correlated i.e. the two variables do not tend to increase together, as one increases, the other decreases.

DISCUSSION

The interpretative model for this study is the ATO model which involves the following stages of evaluation: Antecedent, transaction and outcome.

Antecedent

The results of the analysis show that most chemistry students do not have access to learning facilities such as chemistry practical textbook, library, computer, laboratory apparatus, internet facilities, good learning environment among others. This is an indication that learning facilities are not available to students especially in the aspect of chemistry practical and this might have a negative consequence on their overall performance in chemistry. This view corroborates Ibrahim (2023), who established that students' performance in chemistry keeps falling due to inadequate usage of learning facilities. The result also aligns with Aloys et al. (2023) who reported that science materials and equipment were scarcely available in schools. Similarly, Edissa et al. (2023) listed inadequate equipment among the challenges of teachers and students in chemistry practical.

By implication, poor learning facility in chemistry practical can reduce students' understanding in chemistry: it can bring about insufficient practical skills which may have a negative impact on their achievement, and it can also lead to disengagement and lack of motivation in chemistry.

More so, the study also establishes that there is no significant relationship between students' achievement in chemistry practical and the teacher's factors. Teacher's factors such as years of experience of teacher and educational qualification could not affect students' achievement in chemistry practical. By implication, the longer a teacher stays on the job does not determine his efficiency in the job, similarly the qualification of teacher may not determine his job performance, what matters here is the condition of teaching practical such availability the availability laboratory equipment and accessibility to good and quality learning facilities. Even if teachers are qualified with many years of experience, if learning facilities are inadequate, students' achievement in this regard may suffer a great setback.

Transaction

Analysis of the results from this study shows that students possess practical skills in chemistry but at a varying degree: some skills are highly possessed by students such as manipulation, classification, experimentation and drawing skills while skills such as observation, measurement, numeracy, recording and communication skills. When practical skills are inadequate among the students this can have various effects on student both in the classroom and outside the classroom: it can impact students' achievement negatively, it can hinder their conceptual knowledge in chemistry, it can reduce their job opportunities since most employers seek graduate with practical experience, it can reduce their competitiveness in the job market, it can hinder their research capabilities and thus make it difficult for them to pursue advanced studies in science, it can reduce their self-assurance and confidence and hinder students' continuous learning. Emphasizing the importance of these resources, Ibrahim (2023) advanced that these resources can help the learning process be successful.

Outcome

The finding of this study establishes that learning materials positively affect students' achievement in chemistry practical. By implication, poor learning facilities in chemistry can detrimentally effects on students' achievement in chemistry practical. This finding aligns with Olayinka (2016) who expressed that effective usage of instructional materials can have a meaningful impact on students' achievement in learning.

More so, the result of the analysis shows that there is no statically significant linear relationship between teacher's factors and students' achievement in chemistry practical. By implication, most of the teacher's factors such teacher's perception about chemistry syllabus, year of experience and teacher's education qualification as identified in this study have no statically significant relationship with students' achievement in chemistry practical. Teacher's factor such as years of experience of teacher could not impact students' achievement in chemistry practical simply because number of years in a job may not translate into a meaning job performance, that is the older you are in the job, the less your contribution may be to students' achievements. This result is contrary to Ene et al. (2022) who expressed that teacher's years of experience affect students' academic performance. The result is also contrary to Kenni (2019) who established a positive relationship between teacher's factors and students' engagement in chemistry. Also, the finding disagree with Jean-Louis et al. (2018), who established a positive relationship between teacher's related factors and students' and students' s achievement. By implication, there is a need to investigate further other teacher's factors that may affect students' achievement in chemistry practical.

Similarly, this study establishes that students' practical skills in chemistry has a statically significant linear relationship between students' practical skills and students' achievement in chemistry practical. By implication, practical skills of students in chemistry practical stand to affect their performance in chemistry. Practical skills are those scientific traits which students exhibit which will improve their conceptual understanding in chemistry and in turn affect their achievement negatively if not well acquired.

Implication of the Study

The findings of this study have several implications for students, teachers and education stakeholders.

Hand-on experiences reinforce theoretical concepts which will enhance understanding of students about concepts in chemistry. A quality practical work in chemistry would help the students to develop:

1. Problem-solving skills,
2. Laboratory techniques and
3. Critical thinking.

Regular practical activities aid knowledge retention and learning in chemistry, it could improve students' interest in chemistry, it could prepare students for careers in chemistry related fields.

A quality chemistry practical session would help students to connect theory to reality, it could reinforce theoretical concepts in chemistry, and it would help students to develop scientific skills, attitude, and processes. It could also bring about peaceful co-existence among the students, especially when they are placed in a group in the laboratory.

The outcome of study could help the teacher to see the need for more practical in chemistry as it will not improve their achievement but also increase their interest in chemistry.

Recommendation

Based on the results of this study:

- ✓ The teacher should try to give more attention to the teaching of chemistry practical in secondary school; that is chemistry practical should be taught on a regular basis.
- ✓ Teachers should improvise materials for teaching chemistry practical in secondary school as lack of laboratory equipment may not be an excuse for not teaching chemistry practical regularly.
- ✓ The government and all stakeholders should endeavor to build more laboratories, equip schools with laboratory facilities, motivate teachers with a good remuneration, improve the condition of teaching for teachers and employ more competent and qualified chemistry teachers.

CONCLUSION

The evaluation of chemistry practical in public senior schools in Ibadan, Nigeria, has been able to establish that chemistry practical has many advantages on students' learning and their achievement in that regard. The availability of learning facilities has a significant impact on students' achievement in chemistry practical, for students to excel in chemistry; learning facilities must be readily available because it can significantly affect students' achievement in chemistry. Similarly, practical skills which are scientific skills exhibited by students has a significant impact on students' achievement in chemistry practical and they are needed by students of chemistry to improve their conceptual knowledge, to connect theory to learning and practices and to improve their motivation and interest in chemistry, therefore, teacher should look out for the manifestation of these skills in students and help them to improve on those skills.

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REFERENCES

Adesoji, F. A., Omilani, N. A., & Dada, S. O. (2017). A comparison of perceived and actual; students' learning difficulties in physical chemistry. *International Journal of Brain, and Cognitive Sciences, 6*(1), 1-8.

Aloys, I., Ezechiel, N., Celestin, N., & Fidel, H. (2023). Effectiveness of hands-on practical activities in teaching and learning chemistry: An exploration of students' engagement, experience, and academic performance. *African Journal of Educational Studies in Mathematics and Sciences, 19*(1).

Aloys, I., Mbonyubwabo, J. P., Mbonyiryivuze, A., Hagenimana, F., Butera, M., Niyonderera, P., & Ukobizaba, F. (2023). Enhancing understanding of challenging chemistry and physics concepts in secondary schools of Kayonza District through computer simulation-based learning. *Journal of Classroom Practices, 2*(2).

Attah, F. O. (2014). *Effects of two teaching methods on secondary school students'achievement in writing and balancing chemical equations in Nsukka Education Zone of Enugu State* [Unpublished M. Ed project, Department of Science Education University of Nigeria Nsuka].

Edissa, M., Daniel, U., Aloys, I., Ezechiel, N., & Francois, N. N. (2023). Teachers' and students' experiences of chemistry practical in selected day secondary schools in Nyarugenge District, Rwanda. *African Journal of Educational Studies in Mathematics and Sciences, 19*(1).

Ene, C. U., Anyiam, L. I., & Onoja, A. E. (2022) Influence of teachers' years of teaching experience on students' academic achievement in basic education certificate examination in basic science. *AJSTME*, 8(1), 488-494.

Etiubon, R., & Ufonabasi, B. R. (2014). Friday teacher qualification and experience as determinants of quality chemistry education in Nigeria. *Journal of Education and Practice,* 5(24).

Ibrahim, H. M. (2023). Relevance of instructional materials in teaching and learning chemistry (a case study of selected secondary school in Maradun Local Government Zamfara State). *International Journal of Research Publication and Reviews, 4*(2), 337-340.

Jean-Louis, B., Céline, G., Cynthia, V., & Marcel, C. (2018). *Teaching experience, teachers' beliefs, and self-reported classroom management practices: A coherent network.* https://doi.org/10.1177/2158244017754119

Kenni, A. M. (2019). Assessment of teacher's factors influencing secondary school chemistry students' participation in practical class in Ikere Local Government Area of Ekiti State, Nigeria. *International Journal of Research and Analytical Reviews, 6*(2), 377-391.

Nigerian Educational Research and Development (NERDC). (2019). *Report on Educational Development.*

Olayinka, A. B. (2016). Effects of instructional materials on secondary schools students' academic achievement in social studies in Ekiti State, Nigeria. *World Journal of Education, 4*(6). https://doi.org/10.5430/wje.v6n1p32

Stake, R. E. (1977). The countenance of educational evaluation. In A. A. Bellack & H. M. Kliebard (Eds), *Curriculum and evaluation* (pp 372-390). CA McCutchan.

Taber, K. S. (2014). *Student thinking and learning in science: Perspectives on the nature and development of learners' ideas*. Routledge. https://doi.org/10.4324/9780203695081

Taber, K. S. (2023). The role of 'practical' work in teaching and learning chemistry. *The School Science Review, 96*(357), 75-83.

Udogu, M. E., & Emendu, N. B. (2017). The impact of practical activities in chemistry laboratory exercises in schools in Nigeria. *International Digital Organization for Scientific Research Journal of Experimental Sciences, 2*(3), 59-67.

West African Examination Council (WAEC). (2022). *WAEC chief examiners' reports*. The WAEC Press Limited.

Yüksel, M., & Geban, Ö. (2014). A study of the prediction of academic achievement in the chemistry course. *Eğitim ve Bilim, 39*(173), 354-365. https://educationandscience.ted.org.tr/article/view/1285