

# Laboratory Adequacy and Students' Attitude: the Determinant of Educational Outcome in Chemistry Practical in Secondary Schools in Ibadan Less City, Nigeria

Olasunkanmi OGUNDIJI<sup>1</sup>

<sup>1</sup>University of Ibadan, Nigeria

---

## Article Info

### Article history:

Received 2024-09-06

Revised 2024-10-13

Accepted 2024-10-20

---

### Keywords:

Chemistry practical

Laboratory adequacy

Students' attitude

Students learning outcome

---

## ABSTRACT

Chemistry practical facilitates understanding of chemical concepts and assists learners in creating their learning. Studies have revealed inadequate practical work in chemistry and students' low achievement and identified factors that may be responsible for this fallout. This study, therefore, examined if laboratory adequacy and students' attitudes will predict students' educational outcomes in chemistry practicals. The study population comprised 150 students and ten teachers from 5 public senior secondary schools in Ibadan-less city, Nigeria. The instruments used are the Chemistry Laboratory Adequacy Inventory ( $r = .79$ ), Chemistry Practical Achievement Test (CPAT) ( $r = .81$ ), and Students' Attitudinal Scale ( $r = .76$ ). Descriptive and inferential statistics were used. The results revealed students' both positive and negative attitudes in chemistry practicals, low achievement, and inadequate laboratory facilities; that laboratory facilities ( $\beta = .022P > .05$ ); students' attitude ( $\beta = .102P > .05$ ) could not predict students' achievement in chemistry practical; there is no significant relationship between students' attitude, laboratory adequacy and students' learning outcome in chemistry practical. Quality chemistry practicals would enhance students' achievement, attitude, and interest, reinforce theoretical concepts, improve students' problem-solving and practical skills, and enhance personalized learning and teacher professional development. Governments should endeavor to build science laboratories, employ more teachers, and supply schools with laboratory equipment.

*This is an open-access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.*



---

## Corresponding Author:

Ogundiji Olasunkanmi

Department of Science and Education Technology, University of Ibadan, Nigeria

Email: [gbileola2009@yahoo.com](mailto:gbileola2009@yahoo.com)

---

## 1. INTRODUCTION

Technological innovations are essential for development, global connectivity, security, sustainability of the natural environment, scientific awareness about natural disasters, and various environmental issues that are challenging human existence. It helps

individuals grasp straightforward operating guidelines of home appliances; it helps power vehicle engines, comprehend human physiology, implement eco-friendly safeguards, and optimize automobile engine performance. As one of the ways to extend scientific knowledge to society, chemistry is taught as a physical science in secondary school.

Chemistry investigates matter's nature, composition, and properties with the forces that hold them together and the changes they undergo [1], [2]. Chemistry education and science teaching are problem-solving-oriented through scientific testing, observing, and making inferences that are empirically based. Chemistry teaching involves using scientific knowledge to solve human problems by making goods and services for human consumption to meet societal needs. The explanation of the natural phenomenon and how changes occur in nature are well simplified in chemistry; it contributes immensely to human development, sustainable development, and nation-building, among others. As considered by Olufunmilayo [3], chemistry is a crucial development agent for humans and the natural environment. The nature and properties of matter are determined by chemistry experiments founded on verified facts (experimentation) and observations. In resonance with [4], chemistry can be regarded as a physical science that systematically investigates natural phenomena to meet human needs.

Chemistry practical is when laboratory activities are involved, and the students are engaged in hands-on activities. Chemistry is practical-oriented, and its knowledge has a relevant industrial application. Chemistry teaching can be facilitated through laboratory activities, which is the driving force for modern industrialization. The nature, composition, and properties of matter are best understood through hands-on activities in the laboratory. Practical procedures in chemistry relate to the usual way of conducting laboratory chemistry experiments using standard apparatus and reagents. The quantitative aspect of chemistry practical involves measuring substances in which the numerical values with correct units must be stated, while qualitative analysis deals with identifying component ions that a chemical compound such as salt contains [5].

Justin [6] glimpsed that practical work in chemistry can make learners make accurate observations and descriptions of matter, enhance the tangibility of phenomena, and pique and maintain students' curiosity. Conducting chemistry experiments offers numerous benefits, making complex concepts more tangible. Emphasizing the importance of practicality in chemistry, Nigeria's science curriculum includes hands-on activities for every topic. The West African Examinations Council (WAEC) syllabus suggests practical work for every secondary school subject. Practical chemistry requires students to observe, classify, predict, measure, draw, record data, and hypothesize. It also fosters an active learning environment where students can become proficient report writers and manipulators and improve their comprehension of concepts and principles. It makes a significant contribution to students' educational outcomes in chemistry; it facilitates students' participation in the classroom while discouraging abstraction, rote memorization, and inattention; it leads to basic and applied research in chemistry at all educational levels; and it aids in the validation of concepts and laws that students have already learned [7], [8], [9], [10], [11], [12].

---

Chemistry practicals have a significant influence on students' learning outcomes in chemistry. Practical work in chemistry can influence students' learning outcomes in chemistry. Students' learning outcome is the achievement of students in chemistry practical work. Students' learning outcome is their achievement, which reflects their success level through participation in hands-on activities. Like Attah [13], students' achievement in practical work could be referred to as what students have succeeded in doing, especially after their exposure to practical work. In line with Mehmet [14], it could be described as the result of a learning experience in an educational process, typically assessed through exams to evaluate knowledge and skills acquired in educational courses. As a result, chemistry practicals might enhance students' learning objectives.

Nonetheless, research has shown that secondary school students' educational outcomes in chemistry are not encouraging and that sporadic laboratory work contributes to this decline. Associated problems with chemistry practicals may be linked to factors such as the availability of laboratory equipment, students' attitudes, and teachers' perceptions about the volume of the chemistry syllabus. The performance of pupils in various tests, particularly in practical chemistry, has raised concerns among Nigerian education stakeholders [15]. Mukaniyonsenga et al. [16] Identified various factors affecting chemistry teachers and students, such as inadequate classroom size, curriculum coverage, and the amount of time allotted to chemistry on the schedule. Ajaja [17] advanced that no matter how well formulated, the success of any educational objective depends on certain factors such as the teacher, the students, an adequate laboratory, the syllabus, the student population in the class, the government, the availability of facilities, instructional strategies, and the learning environment.

The weaknesses observed in students during practical chemistry examinations can be attributed mainly to inadequate exposure to hands-on laboratory work. Research indicates that practical work is essential for fostering a deeper understanding of chemical concepts and enhancing students' laboratory skills [18]. For instance, a study by Afyusisye and Gakuba highlights that students who engage in practical chemistry experiences tend to develop more positive attitudes toward the subject and achieve better academic performance [19]. Conversely, insufficient practical exposure can lead to confusion and misconceptions as students struggle to connect theoretical knowledge with real-world applications [20]. Furthermore, Vhurumuku's research suggests that many students perceive their laboratory experiences as low in inquiry, which may stem from teacher-centered instructional practices that do not encourage active engagement [20]. This gap in practical experience hampers students' ability to perform well in examinations and limits their overall understanding of chemistry as an experimental science [21]. Therefore, addressing these deficiencies by enhancing practical exposure in the curriculum is crucial for improving students' performance in chemistry examinations.

According to Mogaka [22], utilization of science laboratory equipment is defined as the amount of time students have access to the equipment during chemistry practicals. Students must use the equipment during class or laboratory hands-on learning sessions. Analyzing the availability of laboratory equipment in most schools, Okebukola [23] found that most schools had a laboratory area designated as a classroom, one or two outdated

---

microscopes, a few hand lenses, and a few dried-out specimens in bottles. Laboratory equipment can make the knowledge learned in the classroom more permanent and improve students' performance. Lawal [24] claims that laboratory equipment influences practical learning and makes the classroom real, dynamic, and more relevant. The availability and appropriate use of science laboratory equipment positively impacts students' focus and practical skill acquisition, empowering them to be creative, generate new concepts, and fight poverty and unemployment [22]. According to Adeyemi [25], one of the obstacles to efficient science instruction in educational institutions is the lack of science equipment.

Ghuluze and Mohammed [26] state that the behavioral aspects of students' attitudes toward their practical chemistry assignments affect their academic success. Anxiety and attitude are two significant affective variables that contribute to people's realization. The mental inclination of students toward practical chemistry is known as their attitude, and it can impact the behavioral, affective, and cognitive aspects of learning. According to [20], these affective qualities include practical skills, drive and interest, and comprehension of scientific ideas. In summary, attitudes toward practical chemistry can be created and altered within the context of laboratory experiences. The way that students approach their chemistry practical has a significant impact on their performance. According to Çıbık and Aka [26], college students' attitudes regarding their laboratory experiences can significantly impact how well they learn in the lab and play a crucial part in the growth of their knowledge and abilities.

#### Statement of the Problem

Chemistry practicals are crucial to studying chemistry because they help students grasp chemical concepts, explain chemical reactions in their most accurate form, and allow scientists to conduct research in the field. They also encourage student participation in the classroom and allow for the testing of scientific theories and hypotheses. However, studies have revealed unfavorable findings regarding the practical teaching of chemistry, particularly at the secondary school level. Studies have identified various factors that may hinder students' learning outcomes in practical chemistry and solutions being proffered to improve students' learning outcomes. Despite all these, studies still show the poor learning outcomes of students in chemistry practicals. Consequently, this study identified laboratory inventory adequacy and students' attitudes in chemistry practicals as determinants of educational outcomes of students in chemistry practicals in senior secondary schools in Ibadan less city.

#### Research Questions

The following research questions were raised and answered by the study:

- Q1: How motivated are students to participate in chemistry experiments and investigations?
  - Q2: How well-equipped are the chemistry laboratories?
  - Q3: What are the levels of students' achievement in chemistry practicals?
  - Q3: To what extent will the identified factors predict students' achievement in chemistry practicals?
-

Hypotheses:

The following hypotheses were raised and tested in the study:

- H01. There is no significant difference between students' educational learning outcomes in chemistry practical and laboratory adequacy
- H02. No significant difference exists between students' educational learning outcomes and attitudes in chemistry practicals.

## 2. METHOD

In this study, the ex post facto survey design was utilized. Forty-three public Senior Secondary School II students from Ona-Ara Local Government Area Ibadan, Nigeria, comprised the study's population. Five schools were randomly chosen for the study. Intact classes were employed in each of the chosen schools. With the assistance of chemistry teachers in the selected schools, the researcher administered the questionnaires to the students and the teacher's questionnaire to the teachers in the selected schools. The respondents filled out the questionnaire in their various chemistry classrooms. This took place during the normal period and was collected at the end of the period. This took up to four weeks.

### Scope and Delimitation of the Study

The study is delimited to five senior science secondary schools in Ona-Ara Local Government in Ibadan, Oyo State, Nigeria. SS II science students were selected for the study. A random sampling technique was employed to select five public Senior Secondary Schools that met the following criteria:

1. The school must have completed the senior secondary school I and II chemistry Scheme of work at the time of data collection.
2. The school must have a laboratory where chemistry practicals are being conducted.
3. The chemistry students must have sat for and passed integrated science in their Junior Secondary Certificate Examination (JSCE).
4. Availability of a separate class for chemistry students to prevent undue interference.

### Research Design:

Students' Chemistry Practical Attitudinal Scale (SCPAS) was developed to understand students' attitudes toward Chemistry Practical. The Chemistry Laboratory Adequacy Inventory (CLAI) was developed to assess the state of facilities in the chemistry laboratory. Similarly, the Students' Achievement Test in Chemistry Practical (SATCP) was developed to determine students' achievement in chemistry practical.

### Validation and Reliability

Teachers of chemistry and specialists in science and technology education completed the face and content validity of the instrument. Responses to the SATCP were gathered and assessed for twenty students not included in the sample study. After a week, the same study participants were given it, and their answers were graded. To obtain a reliability coefficient of 0.80, the scores were correlated using Pearson product-moment correlation. Additionally, SCPAS was given to twenty students who were not involved in

the study; using Kr20, the reliability coefficient was determined to be 0.82. Similarly, CLAI was also administered to some sets of teachers who were not part of the study, and the reliability coefficient for the chemistry laboratory's adequate inventory scale was 0.80 using Kr20.

#### Scoring of the Instruments and Data Analysis

The students' responses to the attitudinal scale were ranked as SA = 4, A = 3, D = 2, and SD = 1. The total mark for the achievement was 100. Between 50 – 100 was ranked as “high in chemistry practical achievement, while between 0 – 49 was ranked as low achievement in chemistry practical. The laboratory inventory adequacy scale was also ranked as “Available = 2 and Not Available = 1”.

Key: SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly disagree

#### Procedure

The procedural stages involve visiting the school, seeking permission from the authorities, meeting with chemistry teachers in the selected schools, and administering and retrieving research instruments.

#### Data Analysis

The quantitative data collected were analyzed using descriptive and inferential statistics.

### 3. RESULTS AND DISCUSSION

#### Sub-Section 1

**Q<sub>1</sub>:** How motivated are students to participate in chemistry experiments and investigations?

Table 1. Students' Attitude towards Chemistry Practical

Item	N	$\bar{x}$	SD	Decision
1. I like chemistry practical	180	3.51	.59	Positive
2. I enjoy chemistry practical	180	3.42	.70	Positive
3. I want more of chemistry practical	180	3.35	.84	Positive
4. Chemistry practical makes me patient, more intelligent	180	3.32	.87	Negative
5. Chemistry practical helps my learning of chemistry	180	3.28	.92	Negative
6. Chemistry can be learned better through practical	180	3.28	.89	Negative
7. I learn better in chemistry practical classes	180	3.25	.94	Negative
<b>Ground Mean = 3.34</b>				

Table 1 above presents the analysis of the items on students' attitudes towards practical chemistry. The results show that the first three items reveal a positive attitude of students toward chemistry practicals because they have mean values higher than the grand mean value of 3.34, while the remaining four items show the negative attitude of students

towards chemistry practicals because they have their mean values lower than the grand mean (3.34).

Table 1 shows that out of the seven items on the table, three items revealed a positive attitude of students towards chemistry practicals because they have a mean value higher than the grand mean value of 3.34, while the remaining four items show the negative attitude of students towards chemistry practical because they have their mean values lower than the grand mean (3.34). By implication, students' attitude is favorable to some extent.

To some extent, the result resonates [27], who obtained that students' attitude toward chemistry was positive. The result also, to a certain extent, aligns with Joy [28], who reported positive attitudes of students toward undergraduate chemistry students. By implication, these results indicate a not-too-good attitude of students in chemistry in chemistry practicals and can have a negative consequence on students' learning outcomes in chemistry practicals.

## Q<sub>2</sub>: How well-equipped are the chemistry laboratories?

Table 2. The distribution of Responses of teachers based on the availability of laboratory facilities

S\N	Laboratory equipment	Not available	Available
1	Evaporating dish	4(40.0%)	6(60.0%)
2	Beaker	3(30.0%)	7(70.0%)
3	Wire Gauze	4(40.0%)	6(60.0%)
4	Separating funnel	3(30.0%)	7(70.0%)
5	Condenser	5(50.0%)	5(50.0%)
6	Conical flask	3(30.0%)	7(70.0%)
7	Delivery tube	6(60.0%)	4(40.0%)
8	Boiling tube	4(40.0%)	6(60.0%)
9	Funnel	1(10.0%)	9(90.0%)
10	Stirring rod	1(10.0%)	9(90.0%)
11	Test tube	1(10.0%)	9(90.0%)
12	Dropping pipette	4(40.0%)	6(60.0%)
13	Measuring cylinder	3(30.0%)	7(70.0%)
14	Washing brush	3(30.0%)	7(70.0%)
15	Gas jar	2(20.0%)	8(80.0%)
16	Skip's apparatus	5(50.0%)	5(50.0%)
17	Thistle funnel	8(80.0%)	2(20.0%)
18	Clamp and stand	5(50.0%)	5(50.0%)
19	Distillation flask	2(20.0%)	8(80.0%)
20	Pipette	5(50.0%)	5(50.0%)

Table 2 shows the distribution of respondents based on the availabilities of Chemistry Laboratory Facilities in the selected schools; the result shows that laboratory facilities in schools are not readily and sufficiently available. The frequency distribution of the laboratory equipment goes thus: Evaporating dish, Not Available 4 (40.0%), Available, 6 (60.0%): large quantity was available; Beaker, Not Available 3 (30.0%), Available, (70.0%): relatively large quantity was available; Wire Gauze, Not Available 4 (40.0%), Available, 6 (60.0%): relatively large quantity was available; Separating funnel, Not Available 3 (30.0%), Available, 7 (70.0%): Condenser, Not Available 5 (50.0%), Available, 5 (50.0%): average quantity was available; Conical flask, Not Available 3 (30.0%), Available, 7 (70.0%): relatively large quantity was available; Delivery tube, Not Available 6 (60.0%), Available, 4 (40.0%): not enough quantity was available; Boiling tube, Not Available 4 (40.0%), Available, 6 (60.0%): relatively large quantity was available; Funnel, Not Available 1 (10.0%), Available, 9 (90.0%): relatively large quantity was available; Stirring rod, Not Available 1 (10.0%). Available, 9 (90.0%): relatively large quantity was available; Test tube, Not Available 1 (10.0%), Available, 9 (90.0%): relatively large quantity was available; Pipette, Not Available 4 (40.0%), Available 6 (60.0%): relatively large quantity was available.

Table 2 reveals that not all laboratory facilities are sufficiently available in the schools. By implication, laboratory equipment was not adequately available in schools. This result agrees with Joy [28], who established that facilities for conducting chemistry practicals are inconsequential in secondary schools. Beyond Nigeria, the result agrees with Fayyaz [29], who reported that apparatus and chemicals for conducting chemistry practicals are less provided in Pakistan. ‘No one can place something on nothing.’ Therefore, the lack of laboratory equipment will make it difficult for the teacher to teach practical chemistry, and students will be at the receiving end. This outcome can reduce students’ attitudes and achievement in chemistry practicals because when the equipment in the laboratory is not sufficient, the students may not see a difference between regular classroom teaching and practical class.

**Q3:** What are the levels of students’ achievement in chemistry practicals?

**Table 3. The distribution of Respondents based on the Chemistry Achievement Test**

Chemistry Achievement Test	Frequency	Percentage
Low	94	64.4
High	52	35.6
Total	146	100.0

Table 3 shows that 94 (64.4%) respondents were poor in the Chemistry Practical Achievement Test, while 53 (35.6%) were Good in the Chemistry Achievement Test. This result shows that students’ achievement in chemistry practicals is not good; therefore, their achievement is low. This resonates with the finding of Dillon [6], who revealed that students’ performance in chemistry practicals is low. By implication, students’ educational outcomes in chemistry practicals are not reasonable based on the result of this study. Some factors might be responsible for this, and chemistry educators must determine those factors

that can predict students' educational outcomes in chemistry. More so, students' Low achievement in chemistry could be due to their not-too-good attitude in chemistry practicals and a lack of laboratory facilities.

**Q4:** To what extent will the identified factors predict students' achievement in chemistry practicals?

Table 4. F ratio and the correlation of the independent variables and dependent variable (Chemistry Achievement)

Model	Sum of Squares	DF	Mean Square	F	Sig.
Regression	23.882	7	3.412	.309	.949
Residual	1525.495	138	11.054		
Total	1549.377	145			

R = .124

R<sup>2</sup> = .015

Adj R<sup>2</sup> = -.035

The above table shows that the joint effect of independent variables (Laboratory facilities and Students 'Attitude) on Student Achievement in Chemistry Practical was not significant (F (7,138) = 0.309; R = .015, R<sup>2</sup> = .015, Adj. R<sup>2</sup> = -.035; P > .05).

Table 5. The relative effects of independent variables on Student Achievement in Chemistry Practical

Model	Unstandardized Coefficient		Standardized Coefficient	T	Sig
	$\beta$	Std Error	B		
Constant	14.574	8.468	-.048	1.721	.087
Students' Attitude	-8.176E-02	.054	-.002	-.015	.988
Laboratory Equipment	1.103E-02	.064	.022	.173	.863

The result above shows the relative contribution of each of the independent variables on the dependent: laboratory facilities ( $\beta = .022$ , P >.05) and the attitude of students towards chemistry practical ( $\beta = -.102$ , P >.05) on Students' Achievement in Chemistry Practical. The result indicates that the contributions of each independent variable are insignificant.

## Sub-Section 2: Testing of Hypotheses

The Pearson Product Moment Correlation (PPMC) results in Table 6 indicate no significant relationship between the academic performance of students in chemistry practicals and the availability of laboratory equipment. The calculated P-value of 0.07 is more significant than the 0.05 alpha significance level at a correlation index r level of .967, which is more significant than the .186 r critical at a degree of freedom (df = 1.126). Hence, the null hypothesis, which states no significant difference between students' educational learning outcomes and laboratory adequacy, is hereby accepted.

Table 6. Pearson Product Moment Correlation (PPMC) on the relationship between Educational Learning Outcome and Laboratory Equipment

Variable	N	Mean	SD	F	Correlational Index r	Critical Value	P
Educational Learning Outcome	3.231	31.29	16.45				
Laboratory Equipment	3.231	11.34	7.46	1.126	.967	.186	0.07

\*Correlation is significant at 0.05

Table 7. Pearson Product Moment Correlation (PPMC) on the relationship between students' educational learning outcome and students' attitudes in chemistry practical

Variable	N	Mean	SD	F	Correlational Index r	Critical Value	P
Educational Learning Outcome	1.331	20.29	16.45				
Students' Attitude	5.241	8.64	4.57	2.332	.572	.245	0.09

\*Correlation is significant at 0.05

The result of PPPMC statistics in Table 7 indicates no significant relationship between student's academic performance in chemistry practicals and the students' attitudes. The calculated P – P-value of 0.09 is greater than the 0.05 alpha significance level at a correlation index r level of .572, more significant than the .245 r critical at degree of freedom (df = 2.332). Hence, the null hypothesis is that there is no significant relationship between students' academic performance in chemistry practicals and their attitude, which is accepted.

#### 4. CONCLUSION

This study has been able to establish that students' attitudes towards chemistry practicals are not too good and the laboratory facilities are not adequately available in schools; the students' achievement in chemistry practicals is low; the result of the study also indicates that laboratory equipment and students' attitude in chemistry could not predict students' achievement in chemistry practical. The study also established no significant relationship between students' attitudes in chemistry practicals, laboratory adequacy, and students' achievement in chemistry practicals.

#### Recommendation

Based on the result of this study, the following recommendations are made:

- The teacher should improve on teaching chemistry practicals at secondary school levels.
- Government and other stakeholders should equip schools with laboratory facilities.
- As the identified variables in this study could not determine students' achievement in chemistry practicals, further study should look for more variables that could do so.

- d. Further study should investigate why the students' achievement in chemistry practicals is low and why the identified variables could not determine students' achievement in this regard.

## ACKNOWLEDGEMENTS

I wish to thank all my research assistants for their involvement in the study and the management of the participating schools for allowing me to carry out this study in their various schools. Thank you very much.

## REFERENCES

- [1] I. A. Odesina, *Essential chemistry for senior secondary schools*, 8th ed. Ogun state: Tonad Publishers Limited, 2018.
- [2] O. Y. Ababio, *New School Chemistry; Senior Secondary Science series*, 6th ed. Lagos: Africana First Publishers PLC, 2021.
- [3] O. D. Ayodele, "Re-structuring secondary school chemistry education for sustainable development in Nigerian developing economy," *African Journal of Chemical Education*, vol. 8, no. 2, pp. 93–111, 2018.
- [4] S. U. C. Okoro, "Attaining the MDGs through effective STAN education delivery," in *STAN 54th Annual Conference proceedings*, 2013, pp. 108–118.
- [5] O. E. Sanda, *Modern-day chemistry practical textbook with manual and basic calculations in chemistry for senior secondary schools*. Ibadan: Modern-Day, 2018.
- [6] J. Dillon, *A Review of the Research on Practical Work in School Science*. London: King's College London, 2008.
- [7] S. Mohammed and L. Kinyo, "The Role of Constructivism in The Enhancement of Social Studies Education," *Journal of Critical Reviews*, vol. 7, pp. 249–256, Apr. 2020, doi: 10.31838/jcr.07.07.41.
- [8] M. E. Udogu and N. B. Emendu, "Impact of Practical Activities in Chemistry Laboratory Exercise in Senior Secondary School in Nigeria," *International Digital Organization for Scientific Research*, vol. 2, no. 3, pp. 59–67, 2017.
- [9] P. F. Alves, "Vygotsky and Piaget: Scientific concepts," *Psychology in Russia: State of the Art*, vol. 7, no. 3, pp. 24–34, 2014, doi: 10.11621/pir.2014.0303.
- [10] S. Sjøberg, "Constructivism and Learning," in *International Encyclopedia of Education*, Elsevier, 2010, pp. 485–490. doi: 10.1016/B978-0-08-044894-7.00467-X.
- [11] K. S. Taber, "Constructivism in Education," in *Early Childhood Development*, IGI Global, 2019, pp. 312–342. doi: 10.4018/978-1-5225-7507-8.ch015.
- [12] A. Hofstein and R. Mamlok-Naaman, "The laboratory in science education: the state of the art," *Chem. Educ. Res. Pract.*, vol. 8, no. 2, pp. 105–107, 2007, doi: 10.1039/B7RP90003A.
- [13] F. O. Attah, "Effects of Two Teaching Methods on Secondary School Students' Achievement in Writing and Balancing Chemical Equations in Nsukka Education Zone of Enugu State," University of Nigeria, Nsukka, 2014.
- [14] M. Yüksel and Ö. Geban, "A Study of the Prediction of Academic Achievement in the Chemistry Course," *Eğitim ve Bilim*, vol. SSCI, pp. 354–365, Apr. 2014.
- [15] A. I. Imogie, "A new paradigm for teacher preparation in the 21st century Nigeria," in *the annual national conference organized by the institute of education*, Nsukka: University of Nigeria, 2010.
- [16] E. Mukaniyonsenga, D. Uwizeyimana, A. Iyamuremye, Mr. E. Nsabayeze, and F. Niyonzima, "Teachers' and Students' Experiences of Chemistry Practical in selected Day Secondary Schools in Nyarugenge District, Rwanda," vol. 19, pp. 109–121, Jan. 2023, doi: 10.4314/ajesms.v19i1.8.
- [17] O. P. Ajaja, "Evaluation of Science Teaching in Secondary Schools in Delta State 2 -Teaching of the Sciences," *IJES*, vol. 1, no. 2, pp. 119–129, 2009.
- [18] K. R. Galloway and S. L. Bretz, "Development of an Assessment Tool To Measure Students' Meaningful Learning in the Undergraduate Chemistry Laboratory," *J Chem Educ*, vol. 92, no. 7, pp. 1149–1158, Jul. 2015, doi: 10.1021/ed500881y.
- [19] A. Afyusisye and E. Gakuba, "The effect of the chemistry practicals on the academic performance of Ward Secondary School students in Momba District in Tanzania," *Journal of Mathematics and Science Teacher*, vol. 2, no. 2, p. em019, Aug. 2022, doi: 10.29333/mathsciteacher/12397.
- [20] E. Vhurumuku, "High School Chemistry students' scientific epistemologies and perceptions of the nature of laboratory inquiry," *Chem. Educ. Res. Pract.*, vol. 12, no. 1, pp. 47–56, 2011, doi: 10.1039/C1RP90007B.

- [21] L. Vinko, S. Delaney, and I. Devetak, "Teachers' Opinions about the Effect of Chemistry Demonstrations on Students' Interest and Chemistry Knowledge," *Center for Educational Policy Studies Journal*, vol. 10, no. 2, pp. 9–25, Jun. 2020, doi: 10.26529/cepsj.893.
- [22] M. M. Mogaka, "Availability and Utilization of Physics Laboratory Equipment on Academic Achievement of Students in Public Day Secondary Schools," *International Journal of Research and Innovation in Social Science*, vol. III, no. VIII, pp. 438–441, Aug. 2019.
- [23] E. U. Okebukola, *Science Teachers Handbook*. Inyman, 1997.
- [24] F. K. Lawal, "Resource Utilization for teaching biology towards achieving Millennium Development Goal's objective in selected secondary schools in Zaria Metropolis," in *54th Annual Conference Proceedings of STAN*, 2013, pp. 197–202.
- [25] T. O. A. Adeyemi, "Comparative study of students' academic performance in public examinations in secondary schools in Ondo and Ekiti States," *NCRJET*, vol. 3, pp. 36–42, 2010.
- [26] A. S. Çıbık and E. İ. Aka, "Student views on attitudes towards chemistry laboratory skills," *Online Science Education Journal*, vol. 6, no. 2, pp. 100–113, 2021.
- [27] J. Johnson *et al.*, "Attitude and Achievement of First-Year Chemistry Undergraduate Students at The University of the South Pacific," *Front Educ (Lausanne)*, vol. 7, Apr. 2022, doi: 10.3389/educ.2022.873571.
- [28] N. A. Joy, "Chemistry laboratory equipment and senior school students' performance in north-west nigeria: Implications for counseling," *JCI*, 2017.
- [29] F. Faize, "Effect of the Availability and the use of Science Laboratories on Academic Achievement of Students in Punjab (Pakistan)," *European Journal of Scientific Research*, vol. 51, Mar. 2011.
-