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Improving Students' Practical Titrimetric Skills during Science Experiments through Gender Acculturative Active Learning Approach at Our Lady of Lourdes Senior High School, Navrongo

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Abstract *Background:* This study was designed to improve the titration practical skills of the second-year students of OLL Girls Senior High School at Navrongo. Pre-intervention activities conducted by the researcher showed that the female students lacked requisite skills to carry out titration. *Objectives:* Expose students more to practical activities so as to improve their manipulative skills in titration experiments; for balancing chemical equations, and solving problems involving the mole concept. Literature was critically reviewed on the titration concept. Materials and Methods: The target population was second and third year students of OLL pursuing Agricultural Science Program. However, the final assessed population was the second-year students. The main instruments used were observation, interview and diagnostic tests (pre-test and post-test). Interventional strategies designed and administered mainly as part of laboratory the activities encompassed: [i. laboratory restructuring; ii. review of mole concept; iii. balancing of chemical equations; iv. adherence to laboratory standard safety precautions; v. observation of standard protocols on titration procedure based on GES approved SHS syllabi]. *Results:* Students performances were assessed after administration of the interventions and compared with their previous achievements in titration. The findings generally showcased from post intervention implementation terminal records that, the best students' success rate in titration significantly improved from 75 to ≥ 95% while that of low and average learners pushed from 58 to 74%. *Conclusion:* The difficulties encountered by both teachers and students in the teaching and learning of titration require holistic involvement of stake holders in education to find lasting solutions.

Keywords Titrimetric skills, mole concept, chemical equation, laboratory, safety precaution, student performance

Introduction

The researcher did her final year internship programme at OLL Girls Senior High School at Navrongo in the upper east region of Ghana where she taught second year and final year students' offering Agricultural Science and elective chemistry including other core subjects. The researcher observed students' attitude towards the learning of chemistry and realized the need to carry out a research into the problem causing the negative attitude towards the learning of chemistry and for that matter titrametry, in order to find possible causes and come out with ways to help student develop the needed skills and attitudes towards of chemistry and science as a whole. The following were some of the comments that were made upon interviewing the students at random:

i. "Chemistry is difficult to learn";
ii. "Do we need chemistry in order to qualify for further studies?";
iii. "There use not to be chemistry in agricultural science courses".
iv. "We are forced to offer chemistry as an elective course";
v. "We read and we do not often understand, chemistry seems difficult to us".

Critically examining the learning environment, particularly the nature of the laboratory- the equipment available and the casual interview of students during and after lessons revealed that, they lacked the needed motivation, interest and the equipment in the study of chemistry. Upon further inquiry, the researcher also realized that their attitude was partially due to incoherent presentation of content by teachers. Lack of practical classroom activities hinders the success of chemistry lessons [1].

Moreover, the scientific discipline is composed of two parts; the conceptual structure and the methodological structure [2]. The conceptual structure of science (also known as the products of science) comprises the ideas, theories, postulates, hypothesis *et cetera*, generated as a result of scientific activity while the methodological structure (also known as the process of science) comprises the methods used by scientists in their work which include, observation, measurement, prediction and classification [3]. The two structures are the wings on which science flies. Science must thus correctly be seen both as a body of knowledge and as a body of acquiring and refining knowledge as both teachers and students consider the use of new learning methods and opportunities for experimentation, text construction and validation [4-5]. And, it can not thrive when one of these structures is stressed at the expenses of the other just like how a bird cannot fly on one wing [6].

For effective teaching and learning of science (biology, chemistry and physics) therefore, most of its content should be designed with appropriate activities be it practical, projects or experiments to make the learner have a feel of the subject through hands-on-activities [7]. Each activity associated with aspect of science is to make the teaching and learners of science effective and interesting to chemistry learners in particular which is seen as the Centre of all sciences is mostly perceived to be a difficult subject to learn simply because of the fact that it is mostly taught in abstract [8]. This buttresses that teaching and learning of science in general will be ineffective without the practical aspect of it [9]. Moreover, the new educational reforms place a lot of emphasis on the practical aspect of teaching. Thus, the practical exercises that are carried out in school now form an integral part of the continuous assessment for the award of final grade to students. In fact, up to fifty percent of the continuous assessment is allocated for practical aspect science subjects to buttress the significance of chemistry, physics and other science elsewhere in Qatari Schools [10].

Unfortunately, in many schools, very little attention is paid to the practical aspect of teaching chemistry and in most cases the mode of delivery does not employ modern technological skills [11]. Besides, many teachers spend most of their time teaching them and only carry out the practical exercise in the final year; and often do to exploit the e-learning and meaningful integrated technology options [12-13]. This approach causes a lot of harm to the students because, by the time students are entering the examination room, they do not only lack the techniques and skills that will enable them pass the practical aspects, but also lack a sound foundation in the general principles of chemistry that are made easy through experimentation [14]. In such a situation, chemistry is learnt as a collection of isolated facts that must be memorized and reproduced in examination even though the subject could easily be learnt and understood [15].

Both activities and processes of science should engage students in active curiosity to get them into doing or studying the subject at their own pace [16]. Students use process skills to find out how scientists think and work to investigate their own questions in the manner similar to the way scientists conduct their enquiries [17]. They use process skills to construct knowledge by asking questions, making observations, taking measurements, collection information, organizing and interpreting data, predicting outcomes by manipulating one variable while keeping the constant [18].

Improved learning culture and modern scientific pedagogical skill exhibition of participants at teaching/learning encompass the formulating and testing of hypothesis, developing experiments, inferring reasons for what they observe and communicating models to others [19]. These activities have long been noted of been capable of leading students to make discovery of facts, principles, laws and generalizations which scientists have established [20].
However, the final year students and the present SHS two agricultural science students of OLL Senior High School were found to lack requisite experiences in how chemistry a practical look like based on keen assessment of RPK. From that preliminary observation that students were made to carry out a practical assigned by the researchers. It revealed that, past and present students of the school never had any experience of chemistry practical lessons. Consequently, the students' responses to items such as identification of apparatus and skills such as use of pipette to transfer solutions onto conical flask, reading of volumetric contents, clamping of burette and balancing of chemical equations *etcetera,* as demonstrated during their first preparation of solutions and titration practical lessons showed that their experimental titrimetry capacities were woefully inadequate. This was probably due to the fact that students were not given the opportunity to acquaint themselves or interact with materials in the laboratory and or the appropriate TLAs were not adequately supplied to them for practical and demonstrational lessons. Hence both students could not have translated the theories into practice. According to Boakye and Ampiah, lack of TLAs has constituted a major challenge for many young science teachers, often reducing their capacities to deliver lessons effectively in the sciences [21].

The perceived problem

Lessons held in the classroom and in the laboratory, which gave students the opportunity to express their views in making critical observations, skills of handling and manipulating apparatus and measurements with some basic laboratory equipment were perceived to be some attributes to the progress of students learning process. Students felt reluctant, unconcerned and scared when it comes to learning that required some of the processes, skills and attitudes.

Diagnosis

a. Evidence:

Critical observation made on the learning environment and on students during their first and second practical lessons revealed that, learners could neither identify some of the apparatus nor take accurate reading of the burette and, even pipetting solutions into conical flasks was very difficult for them. When it came to balancing of chemical equations, it looked very new to them. They could not comprehend the whole idea as matter of scientific import.

b. Causes:

i. The laboratory lacked sinks, the tables and benches were so weak. This point to the fact that the laboratory was not a convenient place for practical work.

ii. Insufficient experimental apparatus for each student to have first-hand practice in the laboratory.

iii. Inadequate time allocation for practical activities during science-based lessons.

iv. Improper arrangement and labeling of chemicals and apparatus in the laboratory.

v. Inadequate knowledge on the concept of balancing chemical equations.

Statement of the problem

The pretested skills demonstrated by the second and final year students clearly showed that the basic concepts of titration and its calculations including the balancing of chemical equations could not be properly juxtaposed scientifically by the students. The study was therefore tailored to find out the appropriate steps for adoption towards improving the skills that the science students ought to exhibit in titrimetry.

The purpose and objectives of the study

Titrimetry which is a branch of quantitative analysis in chemistry is seen to support the quote of ten attributed to Confucius, "I forget what I hear, I remember what I see and I know what I do" [22]. This action research was conducted to demonstrate ways of accomplishing these assumptions as a natural part of any class room learning process. The study was therefore, structured to explore and determine the possible constraints hindering the acquisition of some attitudes by students towards the learning of chemistry in second cycle institutions.

Specific objectives of the study were to:

1. expose students more to practical activities so as to improve their manipulative skills in titration experiments;
2. help improve upon student's knowledge in balancing chemical equations;
3. determine measures that could broaden students' knowledge in solving problems involving the mole concept during chemistry practicals.

Research questions

1. Will taking students through titration procedure improve their practical skills in titration?
2. Will students be able to determine specific titer values and use them to do simple scientific calculations during experiments?
3. Will students be able to solve questions involving the mole concept during chemistry lessons on titration?

Significance of the study

The study was timed to address research skill/knowledge gaps in titrimetry and, the expected findings could serve as a guide to improve or make teaching and learning of chemistry more effective and useful through practical activities. Outcomes of the recommendations could address peculiar issues in other schools where titrimetry practice skills are fundamentally abysmal so as to improve the general performance of learners in chemistry.

Limitations of the study

The research was limited to only OLL Girls Senior High School although, it would have been proper to cover other schools. A research of this nature involves high cost and logistics requirements as well as equipment or teaching and learning materials to carryout activities in order to attain maximum results. A larger size student population was targeted for the study but due to the difficulty in dealing with large population, the selected sample frame was limited to 38 second year female students of the OLL Girls Senior High School.

Brief Literature

In the past, economic and political power was based on physical strength, which stood for the population that could fight and produce, but today, it is based on the possession of scientific and technological knowledge. While the world population increases rapidly, nourishment and energy resources are consumed with the same speed. As a result, too many problems mainly environmental matters, threatens mankind particularly pollution and climate and only the societies that have the brain power to use science and technology can cope with the problems mentioned [23-24]. Since the technology which is created by getting support from science, assists in societal development, many societies now attach much relevance to science education [25]. Good quality appropriate chemistry experiments play a vital role in teaching and learning. They can be used to enhance learning and to clarify aspects of theory. Practical activities add to the fun of chemistry and allow students to apply their knowledge and understanding to what they experience. According to Chemistry Science Fair Projects, chemistry is an experimental science [26]. As such, practical work must not be treated as a separate branch of chemistry since chemistry practical's is a means of helping students get a better understanding of concepts [15].

Research work earlier on carried out to find the essence of practical skills to science by Abramoff and Thompson revealed that students who already knew the essence of practical activities and learn through the use of activities can apply them to new situations especially in chemistry [27]. According to Helmenstine, science practical activities provide learners with the opportunity to use scientific equipment to develop the basic manipulative and attitudinal skills [15]. The process needed to develop the skills include; observing, classifying, describing, communication, drawing conclusions and making operational definitions [19]. Laboratory work is usually performance based and science teaching is limited to lectures supported by models, charts and displays. Indeed, there are conditions that foster their situation such as large classes, short periods, inadequate facilities and lack of equipment [26]. David, noted that, without adequate laboratory facilities the science teacher functions in an atmosphere of frustration either the teaching turns to become entirely theoretical or spends too much time on various kinds of improvisation, which could have been devoted to teaching [28].

Sam pointed that, the role of the laboratory is central in high school science course students, pupils and teachers must construct their own understanding of science ideas by conducting themselves well and obeying safety regulations [29]. This knowledge cannot simply be transmitted to teachers, but rather must be developed by students in interactions with nature and the teacher. Meaningful learning will occur where laboratory activities are well integrated as part of the learning sequence [15]. Practical chemistry teaching offers opportunity for students to gain hands-on-experience in the safe handling of chemicals and chemical apparatus. More generally it also provides valuable training in the identification, assessment and control of risks - procedures which can be readily applied to the management of other activities [27]. Practical science activities in Ghanaian Senior High Schools [30] include:

i. Experimentations, where students perform an activity or techniques which illustrates
a message, law or series of points.

ii. Investigation, where students try to find out about a scientific method.

iii. Demonstrations, where a teacher performs experiment in from of a class.

Fraser and Tobin (1990) earlier intimated that “laboratory activities appeal as a way of allowing students to learn with understanding and at the same time engage in the process of constructing knowledge by doing science [31]. The meaning of practical work can be expressed in four broad ways [26]:

i. A means of importing basic laboratory skills.

ii. A means of developing observation skills

iii. A means of illustrating a particular concept.

iv. A whole scientific investigation.

The basic laboratory skills stated by ASE handbook include skills like inferring, hypothesizing, measuring and manipulating [26]. Observational skills include describing objects, classifying and identifying relations between variables. Illustrating a particular concept can be expressed in terms of “proving” a phemeron, concept, law or principle. An example of such an illustration is the concept of “Neutralization Reactions” through titration (tritrimetric practicals). Kulczak explaining some experimental recent skills in titration said, in filling the pipette, hold it straight between the inside of the thumb and the next three fingers should be placed such that the index finger can easily be moved to close the exposed end [32]. The tip of the pipette is always below the surface of the liquid while pipetting. According to syllabus designed by the Curriculum Research and Development Division (CRDD) for elective chemistry for Senior High Schools, practical and experimental skills take 30% out of its three profile dimensions in Ghana [33].

Practical skills involve the demonstration of manipulative skills using tools, machines and equipment for practical problem solving [6]. The teaching of practical skills should involve practical work, case studies and field studies where students will be intensively involved in practical work and in the search for practical solution to problems and tasks [21].

Experimentation involves the demonstration of the inquiry processes in science and refers to skills in planning and designing of experiments, observation manipulation classification, drawing measurement, interpretation, recording, reporting and conduct in field [34]. Practical and experimental skills also refer to the psychomotor domain. A summary of the skills required for effective practical and experimental work are as follows: [1. Equipment handling, 2. Planning and designing of experiment, 3. Observation, 4. Manipulation, 5. Classification, 6. Drawing, 7. Measuring, 8. Interpretation, 9. Recording, 10. Reporting, 11. Conduct in laboratory/Field]. From the literature presentation therefore, it is obvious that, the teaching and learning of titrimetry in chemistry will be more effective if the practical aspect is given the needed attention alongside content presentation.

Methodology

Research design, population and sampling procedure

The action research was designed to find appropriate steps to guide students in practical chemistry in order to enable them improve upon their manipulative skills in titration. The design was based on the fact that students lack the needed skills in titration. It involves pre-intervention and post-intervention activities. The study sample population comprised of 38 second year agricultural science students of OLL Senior High School.

Sampling techniques and research instrument

Purposive sampling technique was used because, the researcher taught chemistry and integrated science in the school. As a result, the second-year students were used as the assessed study population. Data was collected using observation, interview, pre-intervention and post - intervention tests.

Pre-intervention activities

Observation

During the preliminary preparation, observation and screening was done by thoroughly examining the nature of the laboratory while preparinga check list to determine areas of students weakness such as clamping of burettes appropriate eye level for correct readings of volumes, pipetting, how to use one hand to control the clip of the burette and the other hand to swirl the flask, the point at which one should stop equations, balancing of chemical equations *etcetera* (refer to appendix for sample check list).

Interview

Instructed interviews were conducted on students and the head of science department at the OLL Senior High School to solicit information based on the skills required for titration through personal contact during lesson hours where the investigator had direct contact with the students.

Pre-intervention test

A diagnostic test (pre-test) was structured, containing five questions of pencil and paper test to analyze students' strengths and weaknesses in titration skills. A sample of the test can be found in appendix A.

Intervention design/activities

Students were made to go to the science laboratory for practical activities every Thursday and some extra classes on weekends to improve their titration and calculation skills. The following activities were designed to sharpen practical lessons: [i. Restructuring of the science laboratory; ii. Precautionary measures;iii. Titration procedures; iv. How to use titre values in calculations; v. Balancing of chemical equations and the mole ration, vi. Review of the mole concept in relation to quantity of solutes in solutions; vii. Amount concentration (molarity); viii. Mass concentration].

Implementation

Restructuring the learning environment

The investigator constructed an improvised sink for washing hands and titration apparatus, and reconstructed while white card boards were cut and sellotape to serve as white tiles during titration. Students were authorized by the headmistress to make some contributions for the purchase of a medium sized gas cylinder and its accessories and samples of some chemicals for practical activities. This move contributed positively by promoting effective student participation leading to significantly ≥95% good success rate.

Precautions

The researcher organized extra classes for students where she discussed the essence of safety precautions and why it must be keenly observed in the science practice laboratory. Students were introduced to some common precautions before, during and after the titration process. For example, the researcher demonstrated to students the standard procedures for handling, using and washing burettes, pipettes, conical flasks *etcetera*, with water and distilled water and detergents. The students were further made aware that the apparatus before use should be rinsed with the solutions meant for the practical activity.

Intervention to avoid dilution of the solutions

Students practiced what was demonstrated by the researcher while the researcher went round observing and correcting the them within 45 minutes to 1-hour standard lesson review duration.

Titration procedure

Students were taken to the science laboratory where the researcher demonstrated how titration was carried out. Students were independently allowed to observe and conduct the titration activity while the researcher went round to observe and ensure they actually practiced the right skills. Those finding it difficult were given another chance and a helping hand under the following activity and guiding protocol:

i. Washing of titration apparatus.
ii. Rinsing of apparatus with solutions to be used in them.
iii. Clamping of the burette.
iv. Pouring of solution into the burette using funnel and explaining why funnels must be removed after pouring out solution.
v. How to read volume at correct eye level using the burette and pipette.
vi. Opening of stopcock or clip to allow solution to flow out until bottom of the meniscus reaches the upper edge of the first graduation mark at 0.00 cm or any suitable mark such as 0.50 cm, 1.00cm *et cetera*.
vii. How to use the pipette in transferring solution on to the conical flask.
viii. How to use the left hand to control a clip of the burette while using the right hand to swirl the flask and at what point one should stop the titration.
ix. Finally, how to tabulate results and calculate the average titre value.

During subsequent practical lessons, students were taken through standard protocols that they must follow during titrations such as recording of titre values and strike the average titre values to two decimal places, continuation of titration to obtain consistent values *etcetera*. More importantly, they were also taken through the concept of balancing chemical equations and some calculation techniques in titration.

Balancing of chemical equations and mole ratio

The investigators further organized extra classes alongside the normal periods to consolidate students' practical knowledge on the concept of balancing equations. Students were taught to balance chemical equations which normally comprise two parts; products and reactants. A chemical equation should have the same number of each kind of atom on either side of the equation (left and right).Students were taught that; a balanced chemical equation does not alter the formula of the compound since it is absolutely fixed. The students conscientized that chemical equation balancing is done by finding and introducing the appropriate coefficients to ensure no atoms are created or destroyed. Examples of an unbalance chemical equation: $NaOH + H_2OH + H_2SO_4 - Na_2SO_4 + H_2O$. Example of the balanced form of the equation is as follows:

$$2NaOH + H_2 SO_4 - Na_2 SO_4 + 2H_2O$$

After introducing the concept, the investigator engaged students in various exercises on the types of chemical equations such as combustion reaction, displacement reaction and decomposition reaction, double composition, ionic, combination and neutralization reactions. Students were also taught mole ration during the lesson. A final evaluation was carried out by the researcher to ascertain students' level of understanding about the concept.

Calculation techniques involving the mole concept

Worked Example 1.

A solution contains 0.060mol of sodium hydroxide in $250cm^3$ solution. Calculate the concentration in mol/dm^3.

Solution

From definition, concentration of a solution is expressed as the amount of substance (in mols) per unit volume (in decimeters cube) (dm^3) or litres of the solution.

Thus, concentration (c) = $\frac{\text{amount of substance (n)}}{\text{volume of solution (v)}}$

$C = \frac{n}{V} = \frac{\text{number of moles}}{\text{volume of solution}}$

$C = \frac{0.060 \text{ mols}}{0.25dm^3} = 0.24 \text{ mol}/dm^3$

($250 \text{ cm}^3 = 0.25dm^3$)

Worked examples 2.

A solution of trioxocarbonate (iv) contains 5.3g of the solute in 1 litre of solution. What is the concentration in mol/dm^3? [H = 1.0, C = 12.0, Na = 23.0].

Solution

The concentration of the original solution is in gdm^{-3}.

Molar mass of Na_2CO_3 = 2x23 + 12 + 3x18 = $106gmol^{-1}$

Mass of Na_2CO_3 = 5.30g

Volume of solution = $1dm^3$

Amount of $Na_2CO_3 = \frac{\text{Mass}}{\text{Molarmass}} = \frac{5.3g}{106g/mol}$

= 0.05 mols

Concentration $= \frac{n}{V} = \frac{0.05}{1dm^3} = 0.05 \text{ mol}/dm^3$

Worked example 3:

About 0.014 moles of sodium hydroxide reacted with $30cm^3$ of a solution of H_2SO_4 of an unknown concentration. Calculate the amount of H_2SO_4 using the mole ration of the reaction.

Solution

Reaction = $H_2SO_4 + 2NaOH - Na_2SO_4 + 2H_2O$

The mole ration of H_2SO_4 to NaOH is 1:2. Therefore, 0.014 moles of NaOH must be neutralized by 0.014 = 0.007 mole of H_2SO_4.

Alternatively, $\frac{n\ (H_2SO_4)}{N\ (NaOH)} = \frac{1}{2} = n\ (H_2SO_4)$

$= \frac{n}{2} (NaOH) = \frac{0.014}{2} = 0.007$ moles.

Students were evaluated after the lesson to find out whether the objectives were achieved.

Post-intervention

During the post intervention period, the researcher administered a post-test with the same difficulty level as the one previously used during the pre-intervention studies. This was to evaluate the success of the intervention strategies employed to enhance students' understanding of the titration activities conducted and the skills needed to independently carry out titration experiments by the learners.

Data collection and Analyses

The tests were administered to students by the researcher. The students were given enough time to respond to the items and were subsequently collected. The researcher also conducted some observation and informally interviewed the students to solicit additional information from them. Students responses on the observation interviews and the pre-test were organized into frequency counts and converted into simple percentages for further discussion.

Results and Discussion

Nature of the learning environment and students' skills

An observation study that was conducted concerning the nature of the learning environment (laboratory) and on students to know the skills they already have. It revealed that, the students comprised of 17 females and 21 males with their ages ranging from 12 to 16 years. The information gathered from the observation is presented in table 1 with the observation check list. The results in table 4.1 showed that the learning environment was not conducive enough for practical lessons. The laboratory was without a sink. Benches were weak and not large enough for practical activity, no gas supply for heating, lack of some chemical samples *et cetera*. Findings from the observation and interviews also revealed the students lacked requisite manipulative skills for titration and other practical tasks execution. To address these problems, the researcher therefore designed intervention activities such as allocation of some periods for practical activities every week and extra classes, review of the mole concept in relation to quantity of solute, balancing of chemical equations and mole ration, adopting precautions in the laboratory and standard titration procedure.

Table 1: Nature of the laboratory and students' skills in titration

Item	Check list	Skills possessed		
		Good	Average	Poor
1.	Is the science laboratory conducive enough for practical activities?			✓
2.	Are students able to wash apparatus, rinse them and handle them properly?			✓
3.	Are students able to clamp burette properly?		✓	
4.	Do they have ability to read volume at correct eye level using the burette and pipette?			✓
5.	Are students able to balance chemical equations correctly?			✓

Post-intervention observation

The data in table 2 shows the level of titration skills acquired by students after the intervention. It clearly indicates that, the levels of titration skills acquired by students after the intervention have improved tremendously as compared to the observation made during the pre-intervention stage of the study.

Table 2: Level of titration skills acquired by students after the intervention

Item	Check list	Skills possessed		
		Good	Average	Poor
1.	Is the laboratory conducive enough for practical activities?	✓		
2.	Are students able to wash, rinse and handle the apparatus properly?	✓		
3.	Are students able to clamp burette properly?	✓		
4.	Do students have the ability to read volume at correct eye level using the burette and pipette?	✓		
5.	Are students able to balance chemical equations correctly?	✓		
6.	Are students able to solve questions involving the mole concept	✓		

correctly?

Table 3: Analysis of students' performance in the pre-test

Item	Number of students who scored item correctly	Valid %
1.	9	23.68
2.	3	7.89
3.	15	39.49
4.	17	39.47
5.	5	13.16

The data in table 3 elucidate the performances of students in the pre-intervention test before the intervention activities. The results reveal that nine students representing 23.68% scored test item 1 correctly. About 3 students scored item 2 correctly, representing 7.89%. About 15 students scored item 3 correctly, representing 39.47% while 17 students scored item 4 correctly and 5 students cored item 5 correctly representing 44.74% and 13.16% respectively. The data in table 4 presents an analysis of students' performances in the post-test.

Table 4: Analysis of students' performances in the post-test

Item	Number of students who scored test item correctly	Valid %
1.	35	92.11
2.	28	73.68
3.	31	81.58
4.	36	95.74
5.	38	100

From Table 4, about 35 students representing 92.11% scored test item 1 correctly whilst 28 students representing 73.68% scored test item 2 correctly. About 31studentsrepresenting 81.50% scored test item 3 correctly whilst 36 of them scored item 4 correctly representing 94.74%. The entire students scored item 5 correctly representing 100%.

The first research question posed was on: whether taking students through titration procedure will improve skills initiation? And will procedure improve their practical skills in titration? The response analyses, clearly revealed that students' performances in the pre-intervention test were not encouraging considering the number that passed test item 1. Nine students representing 23.6% and 35 representing 92.11% actually passed test item 1 in the post-intervention test. This shows that, there was a great improvement after the intervention. The performance in test item 2 was very poor during the pre-intervention test where only 3 students representing 5.26% passed. The result of the post-test intervention indicated that, students' skills had improved significantly because test item 1 showed a corresponding 81.58%. This goes to explain that, students' skills had significantly improved. This affirms the literature stipulation that chemistry practical is a means of helping students get a better understanding of concepts and improves learners' achievements in classes through hands-on practical learning approaches [1,7,9].

The second research question focused on whether students will be able to balance chemical equations after titration. The study however revealed that students' performances in the pre-intervention test were poor considering the number that passed in the pre-test and post-test intervention. The valid response rates were 44.74% and 94.74% for the for the pre-test and post-test respectively. Considering the two test results, it is worthy of note that, there was an improvement in students' performance which corroborates well with recent discovery that identification and application of appropriate interventions improve students' achievements in chemistry practical lessons [35]. Characteristically, the effectiveness of an intervention for instance is entirely about making good, the missing knowledge by revisiting the subject contents already covered in chemistry lessons [36-37]. This could be an activity to revisit knowledge, identify processes, label diagrams, or focus on the explanation of keywords in titration (example, dissolve, solvent, solute, solution, titre value, *et cetera*) by giving proper interpretations to their meanings to help the learners discover new ideas or demonstrate scientific concepts concisely [38].

The third research question was on whether students will be able to use their titre values to solve problems involving the mole concept? And the revelations regarding this result directly reflected on the students' performances. Their performances on calculations involving the mole concept were very low, considering the number of students (5, representing 13.16%) who passed test item 5.However, the performance on the same concept was 100% indicating that, students understood it properly and subsequently performed excellently on test item 5 during the post intervention test. Luciano *et al.,* indicates the importance of identifying the relationship between variables in a particular concept such as the mole concept in chemistry practical work [35]. Improving practical lesson delivery though appropriate post interventions has demonstrated useful effectiveness in class room lesson achievements, particularly for pre-service senior high school teachers whose technological pedagogical content knowledge asynchronously require constant practice skill development [39]. Generally, it was deduced that the students' skills in titration consequently improved because of exposure and participation in experiments they conducted themselves, guided by the investigators as well as school supervisors. Hence, the improved titrimetry skills acquired will enable learners obtain better WASSCE results to advance their educational career development in both pure and applied chemistry subjects at College, High Diploma and University levels.

Conclusions & Recommendations

The basic objectives of this lesson were to find ways of improving the skills of students in titration at OLL Senior High School. To achieve this objective, the investigators made use of observation interviews and diagnostics tests involving pre-intervention and post-intervention tests to sequester relevant information. It clearly revealed that many teachers spend most of their time teaching the theory, denying the students relevant practical exposure at the early stages of learning chemistry. When students are given a very good foundational practical skills, it projects their understanding of most theoretical concept and performance in chemistry. Besides, most schools do not give science its value in the teaching and learning processes. Laboratories are not often well equipped for the teaching and learning of science which invariably involve practical activities. They hardly schedule even a single practical lesson period in a week. The study also revealed that, in some cases, the chemistry teachers are not well grounded in the subject matter. Some schools or designated classes did not even have professional science (particularly chemistry) teachers to teach. This situation casts deleterious effects since it will usually take some time for a school to get well trained chemistry teacher(s). This unexpectedly results in the poor performance of students at WASSCE in due to non-completion of the chemistry syllabus.

The difficulties encountered by both teachers and students in the teaching and learning of titration require all stake holders in education to come on board to find lasting solutions. The study therefore recommends effective implementation of the following steps to address the low performance of students in chemistry:

1. School authorities should ensure that, appropriate learning environment (laboratories are well equipped for practical activities).
2. Teachers should make their lessons students centered by adopting various activity-oriented approaches which allow the learners to create meaning of scientific (chemistry) concepts.
3. Teachers should try to introduce students to practical lessons at the early stages of learning to completely cover the practical aspect of the syllabus. This will also enable students to acquire the needed skills in titrimetry.
4. Chemistry contains a lot of complex scientific words or terms which sometimes hampers students' comprehensibility. Science teachers should therefore, use very simple English to enhance student's understanding of real concepts.
5. Teachers should prepare in advance and be well vested in the subject matter they intend to teach.
6. Teachers should also ensure that, certain topics which are very much related to practical concepts are treated properly before introducing students to such practical skills.
7. Students should also be given the opportunity to practice what they have learnt in order to develop their skills. More importantly, teachers should include practical exams in their end of term examination and not only during final year mock examination.

Admittedly, there were short comings in this work which particularly points the limitation that -teachers who are not well versed in the subject matter, turn to mislead the students into getting chemistry concepts wrong. Thus, the study proposes some measures to mitigate the gaps on educational policy initiatives crafted towards the advancement of research into chemistry and science education:

1. In titrimetry, constant practice will make one perfect. Students should therefore endeavor to constantly improve their titrimetric skills any time the opportunity comes. This can be done through constant participation in practical lessons.
2. Educational authorities should build modern science laboratories in all Senior High Schools to help students perform efficiently in practicals, especially in titrametry.
3. More frequent in-service refresher training courses should be organized for science teachers by GES whereby teachers could discuss the various strategies to use in simple practical lessons delivery especially in titrimetry.
4. The GoG should provide special packages, incentives or scholarships to students who offer pure science in the secondary schools to motivate them in reading science at all levels of education.

Scientific Ethics Declaration

The author(s) declare that the scientific ethical and legal responsibility of this article published in this journal belongs to them.

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Additional Information

Appendix A

Pre-intervention test questions.

1). Identify the following apparatus by assigning their letters against the names listed.

Diagram here.

Conical flask

Burette

Pipette

2). What is the correct eye-level for reading volume from the burette?

Diagram here

3). During acid-base titration, which of the following solutions is normally put in the burette?

a) base b) Acid

4). Which of these is a balanced chemical equation?

(a) $Na0H + 2HCl – Nacl_2 + H_20$(b) $Na0H + HCl – NaCl_2 + H_20$

5). B is a solution prepared by dissolving 22.0g of KOH in 250ml of distilled water. Whatis the concentration in mol/dm^3?(a) $0.39moldm^{-3}$ (b). $1.56\ moldm^{-3}$ (c). $0.225\ moldm^{-3}$

Appendix B

Evaluation questions during intervention.

A is 0.100m hydrochloric acid solution

B is a solution containing 8.00g impure

Na_2CO_3 perlitre of solution.

a). Put solution A into the burette and titrate it against $25cm^3$ portion of solution B using methyl orange as indicator. Repeat the titration to obtain three (3) consistent values. Tabulate your results and calculate the average volume of the acid used.

b). Write the balanced equation for the reaction.

c). From the results and information given, calculate the concentration of B in $moldm^{-3}$.

Appendix C

Post –intervention test questions

1). Which of the following apparatus is using clamped on the retort stand during acid base titration?

(a). Measuring Cylinder (b). pipette (c). burette

2). Which of the following solutions is normally measured into the conical flask acid-base titration?

(a). Acid (b) base

3). A student forgot to remove his funnel after transferring acid into the burette. How will that affect his work? (a). it may increase the concentration of the acid (b). it may reduce the titre value?

4). A solution contains 0.060 mols of sodium hydroxide in 250 cm^3 of solution. Calculate the concentration in moldm-^{3}. (a) 0.015 $moldm^{-3}$ (b). 0.24 $moldm^{-3}$

5). Which of the following chemical equations is balanced?

(a). $Na_2CO_3 + HCl - NaCl + H_2O + CO_2$ (b). $Na_2CO_3 + 2HCl - 2Nal + H_2O + CO_2$

Glossary

Titrimetry: A process use to determine the concentration of a substance by adding small, measured amounts in volume of another substance whose concentration has accurately been determined with which it reacts.

Titration: A process in which a solution of known concentration is added in small volumes to a fixed volume of another solution until the end point is reached.

End Point: Point of neutralization Determined by using a suitable indicator examples include methylorange, phenolphthalein etc.

Titre value: The volume of solution from the burette which reacted with the other to the end point.

Pipette: A measuring instrument use measure the accurate volume of a solution of an unknown concentration during titration.

Burette: A measuring instrument use to measure the accurate volume of a solution of a know concentration during titration.

NaOH: Sodium hydroxide Solution

H_2SO_4: Sulphuric Acid

HCl: Hydrochloric acid

H_2O: Water

KOH: Potassium hydroxide

GoG: Government of Ghana

GES: Ghana Education service

WASSCE: West African Senior Secondary School Certificate Examination

SHS: Senior High School

CRDD: Curriculum Research and Development Division

RPK: Relevant Previous Knowledge

TLAs: Teaching Learning Aids

OLL: Our Lady of Lourdes (OLL)

NIB: Nabrayisa Islamic Basic

AAMUSTED: Akenten-Appiah Menka University of Skills Training and Entrepreneurial Development