EFFECTS OF PROBLEM-BASED AND TEXTBOOK-WITH-ASSESSMENT APPROACHES ON SECONDARY SCHOOL CHEMISTRY STUDENTS' LEARNING OUTCOMES IN FEDERAL GOVERNMENT COLLEGES, SOUTH-WEST, NIGERIA

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ABSTRACT

Enrolment pattern and achievement in Chemistry over the years appears not to have reflected the importance of the subject in the scientific and technological development of the nation. This problem is attributed to poor teaching/learning methods used in schools. However, there is the need to study possible effects of student-centred strategies on learning outcomes in Chemistry. This study, therefore, investigated the effects of three model teaching methods; Problem-Based (PB), Textbook-with-Assessment (TwA), and combination of PB and TwA learning approaches on academic achievements and practical skills of secondary school Chemistry students in South-West, Nigeria.

The study adopted pretest and posttest control group in quasi-experimental setting with 4x3x2 non- randomized factorial design. Opportunity-To-Learn (OTL) and school type were used as moderator variables. Two hundred and eighty-one senior secondary school two Chemistry students drawn from four single-sex and four co-educational Federal Government Colleges participated. Treatments were randomly assigned to groups. For instance, PB was used by group one, TwA was used by group two, PB and TwA was used by group three while conventional method was used by the control group. Chemistry Achievement Test (r = 0.78), Chemistry Manipulative Skill Scale (r = 0.87) and Students' Questionnaire for Assessment of OTL (r = 0.79) were used for collection of data. Chemistry Treatment Manuals were used as guide for teaching in each of the three experimental groups and the control. Descriptive statistics, Analysis of Covariance and Scheffe Post Hoc Multiple Comparison were used to analyse data at 0.05 level of significance.

Learning approaches had significant effect on students' academic achievement ($F_{(3,262)}$=15.88) and practical skills in Chemistry ($F_{(3,262)}$ = 211.59). Problem-Based group scored highest ($\bar{x}$=29.38), followed by combination of PB and TwA group ($\bar{x}$= 27.97), and TwA group ($\bar{x}$=25.64), while the conventional group had the lowest score ($\bar{x}$ =25.06) in academic achievement. In practical skills, combination of PB and TwA group scored highest ($\bar{x}$ = 118.99), followed by TwA group ($\bar{x}$ = 114.32), PB group ($\bar{x}$= 110.75) with conventional group scoring the least ($\bar{x}$ =81.47). School type ($F_{1,262}$ =38.29) had significant main effect on practical skills but not on academic achievement. Opportunity-To-Learn showed no significant main effects on academic achievement and practical skills. However, the three learning approaches and OTL had no significant improvement on academic achievement and practical skills. Treatment and school type had interaction effects on academic achievement ($F_{1,262}$=6-911) and practical skills ($F_{1, 1,262}$= 8.424). Interaction effects of treatment, OTL and school type showed no significant improvement on either academic achievement or practical skills.

Problem-based and Textbook-with-Assessment learning approaches improved the academic achievement of students in Chemistry irrespective of the effect of OTL and school type. Teachers in co-educational colleges, when teaching practical Chemistry, should emphasize its importance to students' understanding of the theory and to improve their examination scores.

Keywords: Problem-Based learning, Textbook-with-Assessment learning, Learning outcomes

Word count: 456

CERTIFICATION

I certify that this work was carried out by Chinwe Christiana NWAZOTA in the International Centre for Educational Evaluation (ICEE), Institute of Education, University of Ibadan.

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DEDICATION

This thesis is dedicated to the Almighty God, the owner of wisdom, knowledge and Intellectual power.

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INTRODUCTION

1.1 Background to the Study

Science is about life and living. As complex as life is, science has so significantly affected it that the world has now become a global community. Chemistry, a branch of science, teaches that everything one sees, touches or/and feels is made up of elements and combination of elements. Elements are the constituents of matter. So, studying Chemistry makes their existence and their interactions popular (Helmenstine, 2001). These interactions and their results, manifest in what is seen today as new discoveries. The pace of this rapid development being experienced in all facets of life, particularly in the advanced countries of the world, is being achieved through men's hard work. These men are products of well-planned school curricula which place emphasis on the development of thinkers and producers through the study of science and technology (Olabiyi, 2002). In Nigeria, provision for this enablement, has been made in Section 1, sub-section 9f, pp (9) of the National Policy on Education, (FRN, 2008). This policy makes provision for educational institutions at all levels to be oriented to the acquisition of competences necessary for self-reliance through innovation. So, educational activities should be centred on the learner for maximum self-development, self-fulfillment and self-reliance. The different stages of education, starting from the pre-primary, through primary, secondary and tertiary education have their contributions to achieving the broad aim of education in the country.

The senior secondary education, which is the focus of this study, is the first stage of the Post Basic Education and Career Development, and is for those able and willing to have a complete secondary education and can proceed to the tertiary stage. It is supposed to be comprehensive and has a core curriculum designed to broaden pupils' knowledge and outlook. According to the National Policy on Education, the broad aim of secondary education within the overall national objectives is; 'Preparation of students for useful living within the society and for higher education' (FRN, 2008). The Policy also states in Section 3, No 34, (pp19) that some of the specific objectives of this level of education are to:

a. *Provide holders of the Basic Education Certificate with opportunity for education of a higher level, irrespective of gender, social status, religious or ethnic background;*

b. *Offer diversified curriculum to cater for the differences in talents, opportunities and future roles;*

c. *Provide trained manpower in the applied science, technology and commerce at sub-professional grades;*

f. *inspire students with a desire for self-improvement and achievement of excellence;*

Section 3, No 34,(p19),(FRN,2008)

The subject necessary to achieve the above stated objectives for science students are, English Language, Mathematics, Physics, Chemistry, Biology or Health Science and others (FRN, 2008). Chemistry as seen above is one of the core subjects for the science students at the senior secondary school level in Nigeria. It occupies a central position among the sciences. At least a credit pass in Chemistry is a prerequisite for science-related courses, such as Medical Sciences, Engineering, and Agricultural Sciences. Chemistry has been identified as one of the veritable tools for solving socio-economic problems; in fact, knowledge of the subject is very relevant to society (Adewunmi, 2006). It contributes immensely to both individual and national development (Akinola, 2007). Chemistry, being an experimental science, provides ample opportunities for students and teachers to learn, and re-learn, thus becoming productive thinkers to enable them solve even their problems in everyday life (Williams, 2003; Adewunmi, 2006). Furthermore, specialists in Chemistry have, through creativity and originality, gained better understanding of the structure and nature of matter. This, in turn, has led to the development of new techniques in the production of new drugs and synthetic products which are alleviating the suffering of the ailing society, contributing immensely towards the provision of basic needs and improving quality of lives generally.

As a science subject, Chemistry is full of activities which enhance the acquisition of certain skills and competences that can make an individual become scientifically literate and self-adaptive. It is a sine-qua-non for national development (FRN, 2004 and 2008). The need to study the subject cannot be ignored because it has a pivotal role in national development and technological emancipation and advancement. It acts as a basic index for understanding the complexities of very important and specialized areas of study in pure and applied sciences (Ogundipe, 2004; Ajanaku, 2006; Akuche, 2007). Also, the spiral nature of the curriculum, places Chemistry, at a very strategic position because it has direct links with other science subjects.

Despite all these advantages, the strategic position of Chemistry among science subjects and for the study of science-related courses in tertiary institutions, there has been a continuous underachievement and low performance by students of the subject over the years. Unfortunately, many students perceive Chemistry as difficult and so tend to avoid it (Bajah, 1992).

From the researcher's experience as a teacher, at Senior Secondary One (SS1) level, which is the introductory stage, many students register to study Chemistry; but at the end of their first year, many of them drop out because they could not cope. It is, therefore, crucial to find out why they drop out or rather cannot cope. It will also be a worthwhile venture to encourage as many students who indicate interest in Chemistry to register, study it till S.S.3 and confidently pass in internal and external examinations. This can be achieved if appropriate moves, as suggested in this study, are made. This encouragement becomes very necessary because of the state of SSCE result in Chemistry between 2007 and 2011, as revealed in Tables 1.1 and 1.2 below.

Table 1.1: NECO Statistics of Entries and Results for the May/June NECO SSCE (2007-2011) on Chemistry

YEAR	TOTAL ENTRY	TOTAL SAT	%	TOTAL CREDIT (A1-C6)	%	TOTAL PASS (D7 & E8)	%	TOTAL FAILED	%
2007	340281	321503	94.48	172515	53.66	87240	27,14	61019	18.98
2008	389012	344766	88.63	253296	73.45	49257	14.29	25595	7.42
2009	415497	402677	96.92	155434	38.60	121398	30.15	84607	21.01
2010	418800	407899	97.40	154956	37.99	152230	37.32	76332	18.71
2011	446456	427765	95.81	99845	23.34	280809	65.65	26702	6.24

Source: Test Development and Record Office of NECO.

Table 1.2: WAEC Statistics of Entries and Results for the May/June WASSCE (2007-2011) on Chemistry

YEAR	TOTAL ENTRY	TOTAL SAT	TOTAL SAT %	TOTAL CREDIT (A1-C6)	TOTAL CREDIT % (A1-C6)	TOTAL PASS (D7 & E8)	TOTAL PASS % (D7 & E8)	TOTAL FAILED	TOTAL FAILED %
2007	432230	422681	97.79	194284	45.96	104680	24.76	111322	26.33
2008	428513	418423	97.64	185949	44.44	114697	27.41	110417	26.38
2009	478235	468546	97.97	204725	43.69	114020	24.33	119260	25.45
2010	477573	465643	97.50	236059	50.69	109944	23.61	98165	21.08
2011	575757	565692	98.25	280250	49.54	151627	26.80	129102	22.82

Source: Test Development and Record Department of WAEC

These tables reveal that the academic performance of the students in Chemistry between 2007 and 2011, showed an obvious down-turn in the quality of the results. A science student, who mandatorily should have a credit pass in Chemistry to study any science or science-related course in the university or other higher institutions, is regarded to have failed Chemistry with D_7 or E_8. Therefore, a pass in credit and above determines the quality of the result each year. If the total percentage of students with D_7, E_8 and F_9 is higher than the percentage with credit passes (as was the case in 2009-2011 in NECO and all except 2010 in WAEC) then the quality of the results in these years covered by this study was really poor.

Federal Government Colleges in Nigeria were established in each state of the federation to serve as model secondary schools under close supervision, maintenance and monitoring of the Federal Ministry of Education. The supervisory and maintenance duties of the Federal Ministry of Education over these schools accord them the certain privileges such as funding and recruiting of teachers. As a result of this, high quality of teachers with many years of experience is available there. Most of their laboratories and workshops are considerably equipped. Also, the selection of students is usually done through the popular national common entrance examination conducted nationwide by NECO, a parastatal of the Federal Ministry of Education. The top-best pupils in this examination are selected for these schools. With these favourable conditions available to the students, it is expected that their terminal examinations' results in NECO and WAEC senior secondary school certificate examinations would always be good. Unfortunately, that has not been the story in recent times.

The SSCE results of some of these colleges are so discouraging, which also contributed to the researcher's interest on them to find out what must have been the cause. However, the study was focused on Federal Government Colleges in South-West educational zone of Nigeria. The NECO and WAEC analysed results of the sampled schools represented by numbers 1-8 as displayed on Tables 1.3a-d and figures 1-4 and covering the study period of 2007-2011, were collected, studied and scuitinised. The primary reason was to find the likely causes of the low achievement in Chemistry.

Analysis of NECO and WAEC Results of the sampled Schools

Table 1.3a: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

SCHOOL 1		No. Sat	A1-C6 %	D7-F9 %	SCHOOL 2	No Sat	A1-C6	D7-F9
2007	NECO	111	74.8	25.2		281	70.5	29.5
	WAEC	111	79.3	20.7		278	91.7	8.3
2008	NECO	121	75.5	24.5		181	70.2	29.8
	WAEC	124	94.4	5.6		241	97.9	2.1
2009	NECO	134	74.7	25.4		165	98.8	1.2
	WAEC	132	42.4	57.6		144	67.4	32.6
2010	NECO	157	49.7	50.3		162	84.0	16.0
	WAEC	157	59.2	40.8		158	100	0
2011	NECO	134	42.5	57.5		187	28.3	71.7
	WAEC	136	73.5	26.5		180	63.9	36.1

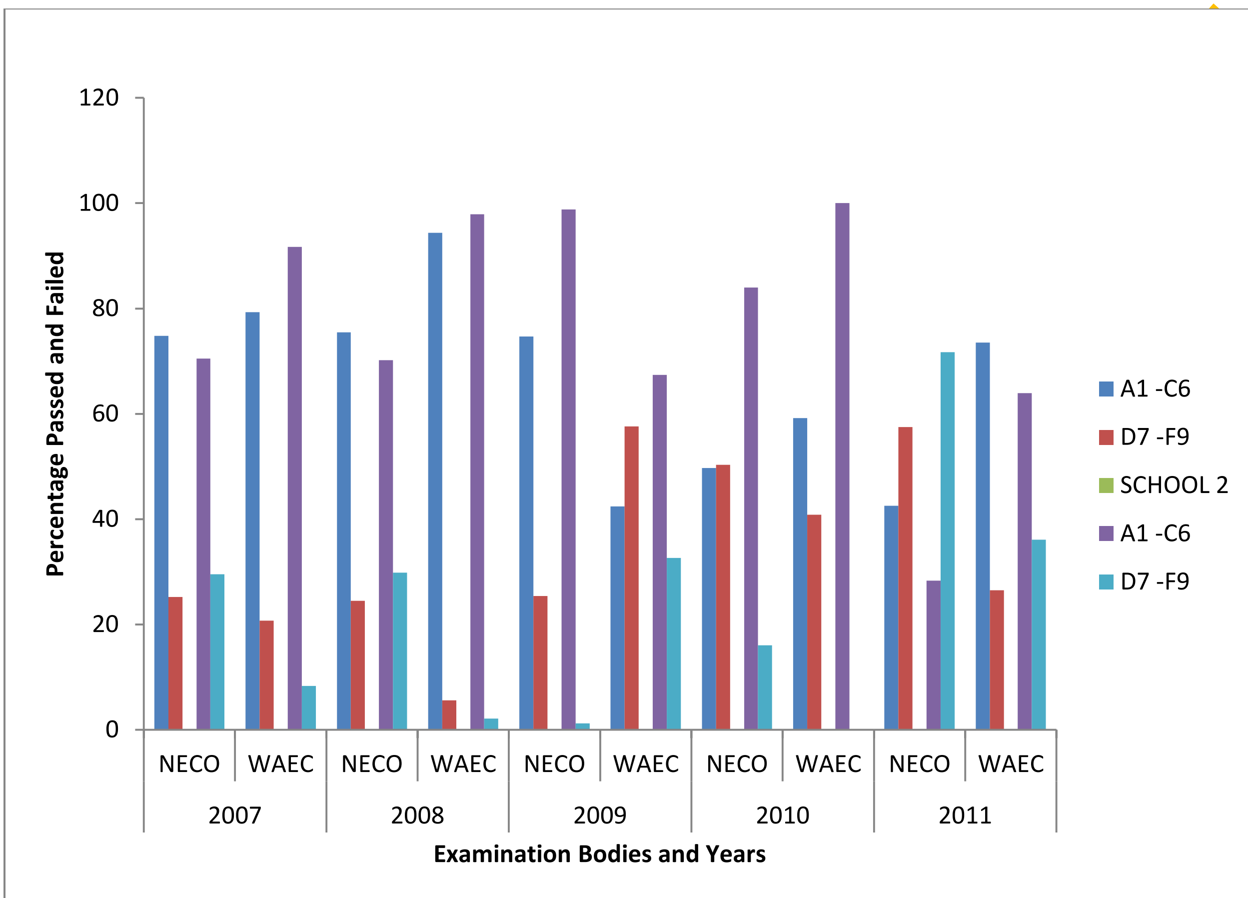

Figure 1.1: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

Critically looking through the analysed results for school 1 on Table 1.3a as well as Figure 1.1, the NECO results of years 2007-2009 were consistently good, but in 2010 and 2011 the performance became so bad that the percentage that made D7-F9 was higher than those that made credit and above in Chemistry. The WAEC results on the other hand, were very good in 2007-2008 but nose-dived badly in 2009 and 2010 only to pick up again in 2011. School 2 results in NECO were consistently very good between 2007 and 2010 but became woeful in 2011 with 71.7% scoring D7-F9 and only 28.3% scoring credit and above. However, they had their best WAEC result in 2010 with 100% credit pass all through. In 2011, as in NECO, their performance dropped in WAEC but not so badly.

Table 1.3b: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

SCHOOL 3		No. Sat	A1-C6 %	D7-F9 %	SCHOOL 4	No sat	A1-C6 %	D7-F9 %
2007	NECO	210	92.4	7.6		138	49.3	50.7
	WAEC	219	90.4	9.6		138	40.6	59.4
2008	NECO	146	91.8	8.2		127	85.8	14.2
	WAEC	148	100	0		126	74.6	25.4
2009	NECO	180	66.1	33.9		119	33.6	66.4
	WAEC	180	69.4	30.6		127	22.1	77.9
2010	NECO	181	49.2	50.8		134	33.6	66.4
	WAEC	181	82.3	17.7		135	68.2	31.8
2011	NECO	214	51.4	48.6		124	40.3	59.7
	WAEC	211	93.8	6.2		124	41.9	58.1

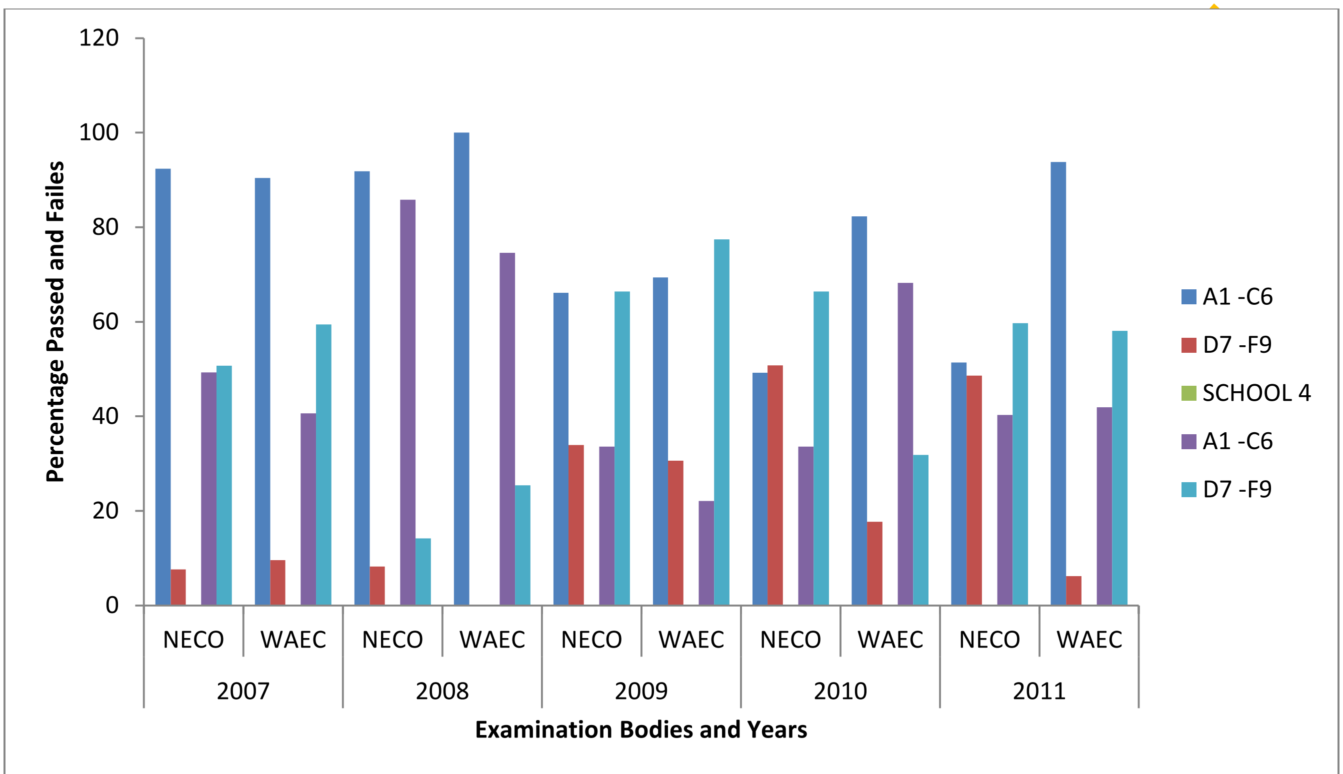

Figure 1.2: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

The NECO result of school 3 in 2007 was their best with 92.4% credit pass as seen on Table 1.3b and Figure 1.2. The results however, recorded a continuous decrease in performance and became worse in 2010, though there was a slight improvement in 2011, but it was not good enough. For the WAEC results, year 2008 was their best-100% credit pass, but the performance dropped in 2009 and picked up again in 2010 and 2011. For school 4, it was only in 2008 that the NECO result was very good, all other years recorded higher percentage of the students scoring D7-F9 than credit passes. Their WAEC results were not better neither, it was only in 2008 and 2010 that the performance showed high credit passes; all other years had high percentage scoring D7-F9.

Table 1.3c: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

SCHOOL 5		No. Sat	A1-C6 %	D7-F9 %	SCHOOL 6	No sat	A1-C6 %	D7-F9 %
2007	NECO	169	81.1	18.9		270	90.7	9.3
	WAEC	163	71.2	28.8		270	97.4	2.6
2008	NECO	140	84.3	15.7		212	97.2	2.8
	WAEC	150	100	0		222	98.7	1.3
2009	NECO	139	76.3	24.0		192	87.0	13.0
	WAEC	140	88.6	12.4		178	77.0	23.0
2010	NECO	130	66.9	33.1		254	81.9	18.1
	WAEC	129	86.1	13.9		258	100	0
2011	NECO	152	45.4	56.1		303	76.9	23.1
	WAEC	153	67.3	32.7		310	99.7	0.3

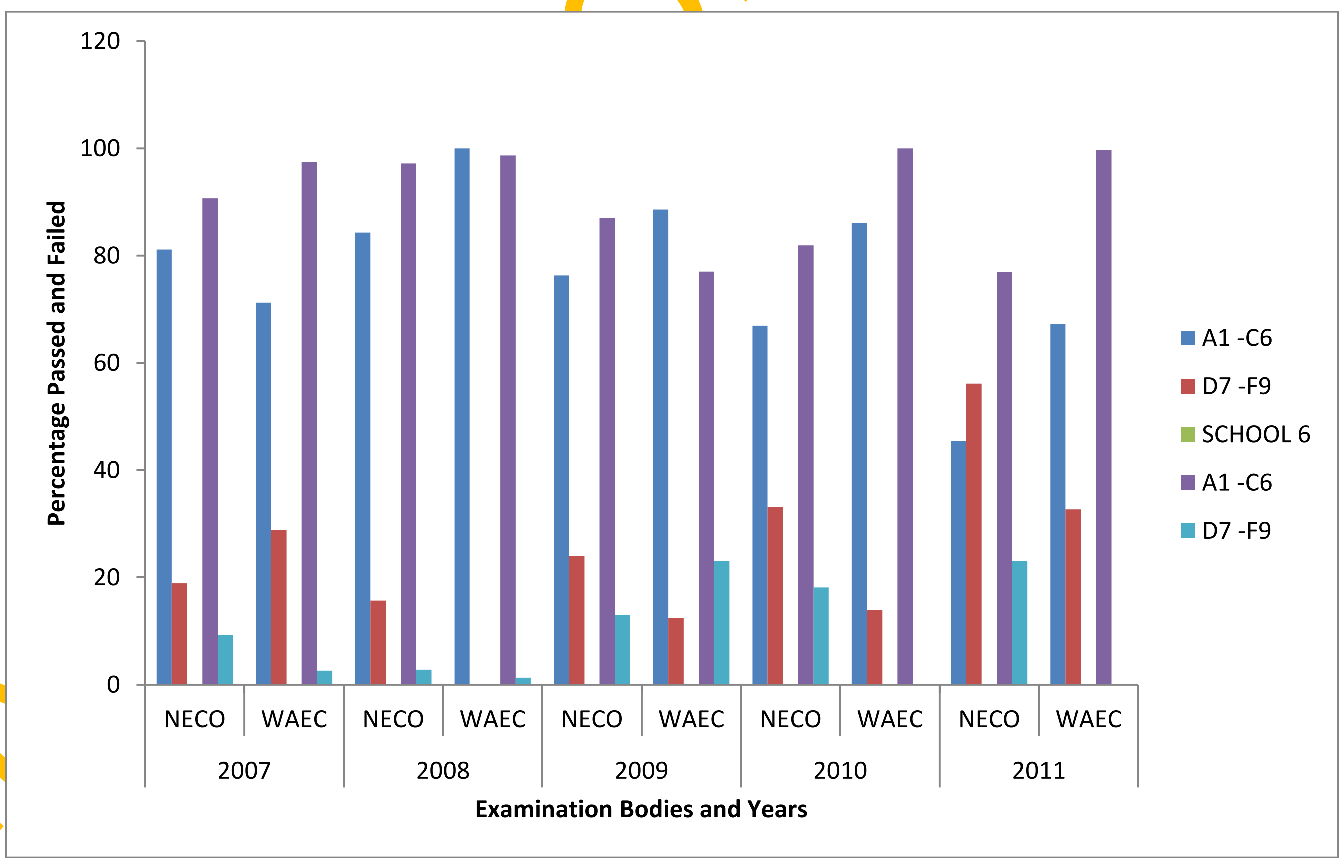

Figure 1.3: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

The NECO results of school 5 were good in 2007-2009, came down the following year and became worst, as low as 56% with D7-F9 performance in 2011 as seen in Table1.3c and Figure 1.3. Their WAEC results were much better because in 2008 they had 100% credit pass and maintained high credit passes till 2011 when they recorded 67.3%, this was regarded as their worse result. On the part of school 6, their NECO and WAEC analyzed results showed a high percentage credit passes throughout the years covered by the study. In fact, for the years 2010 and 2011, their WAEC results recorded almost a zero failure rate.

Table 1.3d: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

SCHOOL 7		No. Sat	A1-C6 %	D7-F9 %	SCHOOL 8	No sat	A1-C6 %	D7-F9 %
2007	NECO	-	-	-		174	64.4	35.6
	WAEC	-	-	-		174	58.6	41.4
2008	NECO	210	37.1	62.9		176	61.9	38.1
	WAEC	88	100	0		124	90.3	9.7
2009	NECO	318	37.7	62.3		143	79.7	20.3
	WAEC	136	80.2	19.8		143	31.5	68.5
2010	NECO	435	41.2	58.8		146	82.2	17.8
	WAEC	217	95.9	4.1		141	55.3	44.7
2011	NECO	451	23.3	76.7		143	25.9	74.1
	WAEC	286	73.8	26.2		141	33.3	66.7

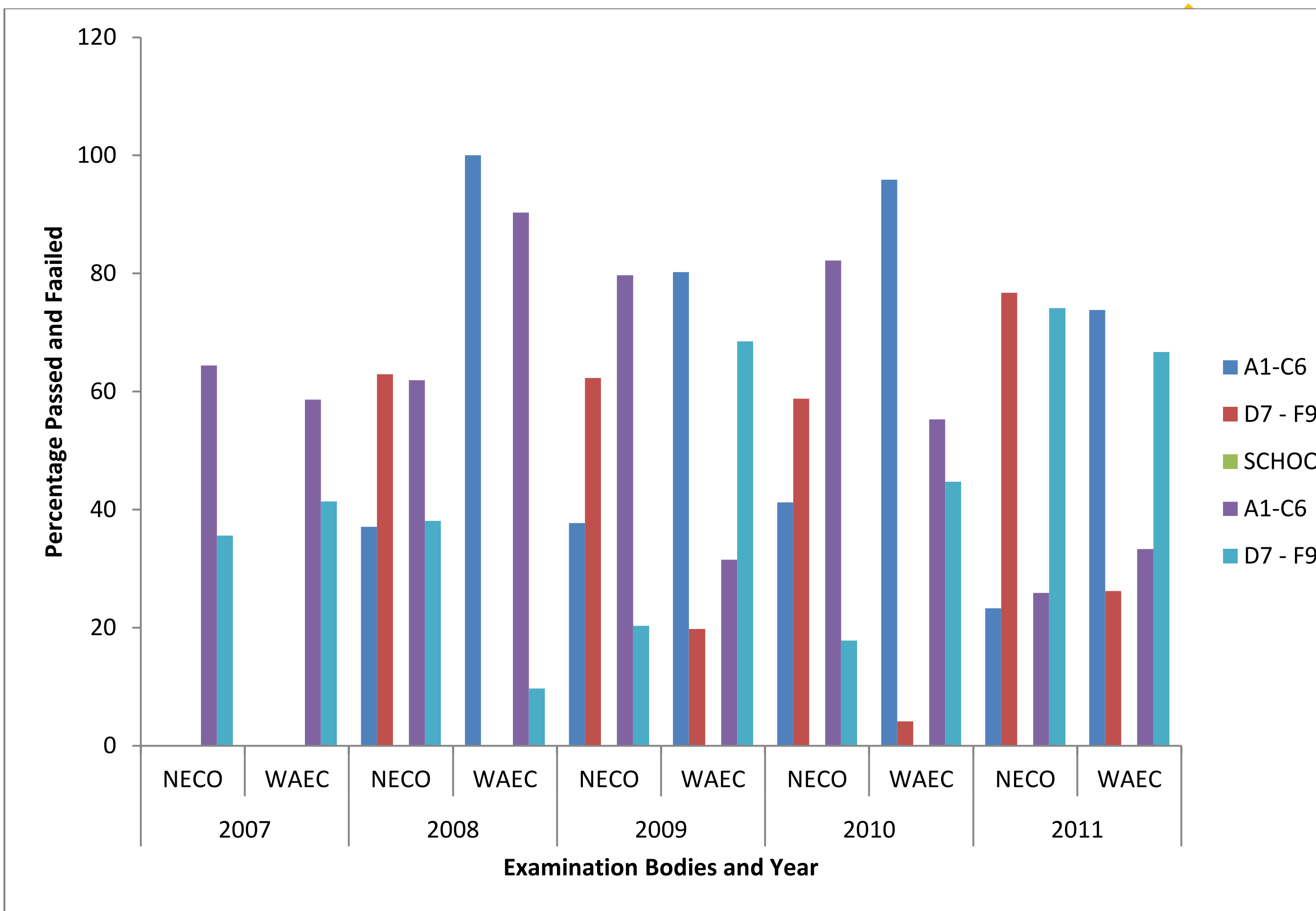

Figure 1.4: NECO and WAEC Statistics of Entries and Results for the May/June SSCE in Chemistry for some Federal Government Colleges for 2007-2011

Table 1.3d and Figure 1.4, had no record of either NECO or WAEC results for school 7, this was because the school did these examinations first in 2008. Being their first attempt, they registered all the students for NECO but selected and registered only their best students for WAEC. Observably, this was the pattern adopted by the school throughout the period covered by this study, evidenced by the quality of their results released by these examining bodies. Finally, school 8 had the most erratic result among the schools used in this study. They recorded their worst NECO result in 2011 and worst WAEC result in 2009 with 74.1% and 68.5% failure rates respectively. Apart from the 2008 WAEC, 2010 and 2009 NECO results, all others were not good enough.

This under achievement or low performance in Chemistry recorded in these schools, which purportedly have many qualified and experienced teachers, reasonably funded by the federal government and having a high caliber of students, was evidence that something was definitely wrong with probably the teaching/learning system being operated in them.

The growing power and importance of Chemistry both in human and material development cannot be undermined, but this picture does not reflect in the performance of the students in the subject nor its popularity; in fact, many students still shun the subject (Jegede, 2003; Ajanaku, 2006b; Odinaka, 2006). It has been observed that so many students fear Chemistry and such fear is characterized by mass disenchantment among the students towards the subject. The end product is declining popularity of the subject over the years (Jegede, 2007). Other variables also discovered from research to be responsible for this are; students poor attitude and self-esteem (Smith,1996; Ogundipe,2004), wrongly perceived difficult nature of Chemistry (Dickson,1995; Nwosu, 2002;), students' anxiety towards the learning of Chemistry (Archaca, 2001; Jegede, 2007), inadequate laboratory facilities and exposure (Bamgbalu,1992; Raimi, 2002; Adeyegbe, 2005; Julius, 2007). Others are, wrong teaching-learning methods (Chia, 1995; Erinosho, 1998; Erico, 2005), assessment procedures (Odetoyinbo, 2006) and very poor or no reading culture among the students (Eneh, 2004). The concern for the above situation, made Maxwell (2006) to call for a new direction in science teaching/learning, including Chemistry. Basically, not only that Chemistry encourages productivity through experiment, it could also be problem-solving through discovery and discovery through reading of textbooks and other textual materials and then experimenting on what has been read for implementation and application.

This needs a new or hybrid approach to classroom instruction--a shift from the conventional methods or what can be described as reformation. Instructions should now be focused mostly on strategic problem-based learning (PB) and student-centred approaches. The development of inquiry skills and abilities fosters and facilitates in learners the ability to take intelligent and wise decisions from available alternatives for problem-solving. The art of Chemistry learning thrives best in these types of approaches that relate abstract situations to reality and solve difficult Chemistry questions from known to unknown.

Researchers at different times have carried out studies on the implementation of other approaches or strategies in the teaching of Chemistry or specific sections or topics of the subject. Ibrahim (2008) investigated the effect of Cooperative Learning Strategy (method) on the learning outcomes in Chemical Kinetics. He notes that different kinds of cooperative methods and their efficacy have been researched, but the results have been inconclusive. So, he based his own study on the efficacy of two modes of Students Teams-Achievement Division (STAD) using SS11 Chemistry students from ten co-educational secondary schools. He also investigated the moderating effects of students' mathematical ability and gender on the dependent variables. His findings reveal that cooperative learning methods enhance understanding of difficult concepts in Chemistry but it has to be without inter-teams competition. He recommended that students with low mathematical ability should not be allowed to enroll for Chemistry.

There are also many topics in Chemistry that are not mathematics based but students' learning outcomes are still below expectation. Raimi (2002) carried out a study on the Problem Solving Technique and Laboratory Skills as supplements to laboratory teaching in students' learning of volumetric analysis. He used SS111 students from twelve schools. Based on his findings, he recommended the combination of the three methods, vis; laboratory methods, practical skills teaching and problem-solving instructional strategy, to enhance the performance of students in volumetric analysis. It should however be noted that such instructional strategies or methods may have to be modified in order to use it for the teaching of other aspects of Chemistry, because it was not stated if the three methods could be used to teach other aspects of Chemistry practical or even other branches of the subject.

From the foregoing, it is obvious that the need for more versatile learning and teaching strategies is desired, which when properly implemented may give the expected outcome in Chemistry learning. This researcher therefore, introduced and tried-out Problem-based (PB) and Textbook-with-assessment (TwA) approaches, as they were seen to be more viable options in teaching/learning science concepts. The first option, the PB approach, was looked at from two dimensions: case studies and chief examiners' report. In the first dimension, learning or teaching topics were identified and taught using case studies of environmental or community problems that needed knowledge of

Chemistry to solve or tackle. Chukwuka (2006) carried out such a community-based research using problem-solving technique to control environmental menace in a community applying knowledge of Biology. In this study, water problem in a school community was addressed under the topic 'Water' using a case study involving SS2 Chemistry students. The problems from hard water and impure water in their school community were tackled applying the PB strategy. Again, the problem was identified through the chief examiners' reports of National Examinations Council (NECO) and West African Examinations Council (WAEC), where students' weaknesses were consistently compiled at the end of every year's marking exercise. Lesson topics were tailored to addressing those issues.

PB, as described by Vasconcelos (2010), is a student-centred method based on the principle of using problems as the starting point for the acquisition of new knowledge. Citing Lambros (2004), he identifies the need to introduce students to real problems that stimulate the search for new information and its synthesis within the context of the problem scenario. PB is also an investigative approach whereby learners in their small groups are needed to proffer solutions or suggestions to tasks or problems in their environment using acquired or current knowledge in Chemistry. The problem-based approach involves problem formulation or/and interpretation, then generation of ideas and plan of actions (Chukwuka, 2006). But Orji (1998) views it as the action steps taken by a learner or group of learners to reach anticipated goals when faced with a problem situation. Stevens (2005) posits that it is bringing real-life situation into the learning of Chemistry. According to Chukwuka (2006) what is actually required in PB is to bridge the gap between the problem state and the solution state by using what has been learnt and being learnt to solve the pressing need of the hour and from there learn more. In other words, the PB approach requires that the learner uses the previously learned principles together with the presently taught or discovered facts to figure out solutions to the problem at hand. Chukwuka (2006), quoting (Selvaratnam and Fraser, 1982; Anderson, 1985), emphasizes that teaching students to solve problems is based on the hypothesis that knowledge is organized and stored in memory in sequential and logical networks and subsequently retrieved in a step-wise manner to solve problems when needed. Ability to successfully do that simply means learning has been internalized. This is why Agina-Obu

(1993). Adewale (2002) and Akuche (2007) state that lack of problem-solving abilities of students has been identified as one of the reasons for students' poor performance in science, especially when the questions require application of skills to answer. This study, therefore, exposed the Chemistry students to the PB strategy and documented its effect on their learning outcomes.

As earlier stated, PB is student-centered and activity-focused. So, practical work thrives more in it, as it encourages students' participation. Students' ability to handle the different apparatus for practical Chemistry counts a lot also. The same chief examiners' reports lamented in almost all the years from 2004-2010 of "inadequate and insufficient exposure of students to practical exercises, inability to link theoretical knowledge with actual practical work" as some of the weaknesses needed to be addressed. Students would not know how to use these apparatus if they are not exposed and allowed to use them adequately enough to establish mastery. Teaching of practical Chemistry focuses on the development of appropriate skills, abilities and competences relating to the psychomotor domain of the child. The objective of this aspect of Chemistry study synchronizes with the purpose of self-reliance advocated in the National Policy on Education. As the cognitive and the psychomotor aspects of the child are developed, the affective would naturally be motivated to give the child self-confidence in handling challenges and interest in the study of Chemistry.

Through adequate exposure to practical exercises, discoveries are made, new things are invented, which may be in agreement or disapproval of an earlier discovery but geared towards solving one life problem or another or breaking through those difficult sections of Chemistry learning. So, the practical nature of Chemistry cannot easily be overlooked because it enhances understanding of even the theory aspect of the topic under study.

This insufficient practical exercise, probably due to inadequate or absence of laboratory materials or any of the reasons already mentioned, contributes to the continuous poor performance of Chemistry students (Akuche, 2007). Discoveries made through practical are immense and easily internalized for possible positive changes in life. Emeke and Odetoyinbo (2004) opine that "pupils have to reinvent science rather than merely following its findings''. This is an encouragement for science students to apply acquired scientific knowledge to daily living in order to ascertain its relevance. The implication of the foregoing is that teachers should encourage acquisition of knowledge in such a way that it leads to the discovery of other knowledge that will directly or indirectly solve one life problem or another and promote better intellectual achievement. This can be done effectively through wide and deep reading of academic materials, like textbooks, and it is not just reading but reading to use the exercises which come along with many texts to aid their deeper understanding. Unfortunately, the majority of the students do not read textual materials. So, something has to be done to make them read.

Weimer (2010) laments that, despite the correlation between reading and academic success, many students are still not committed to reading their textual materials, or they read just prior to examination dates. This is not a new problem, and clearly we cannot simply bemoan the fact that students do not read and just keep watching things go on like that. More efforts have to be made by educationists and other stakeholders. Therefore, this study designed and adapted a learning strategy termed Textbook-with-Assessment learning (TwA) and experimented with it in the teaching/learning of Chemistry.

The TwA approach is geared towards encouraging and compelling students to identify knowledge deficiencies; coordinate their actions, activities and reading pattern; realize goals and continuously monitor understanding. It creates an environment in which students actively participate in the learning process, take responsibility for their own learning, become better learners in terms of time management skills and ability for further discoveries from textual materials, access different resources and evaluate validity of these resources (Araz and Sungur, 2007). The Conventional learning approach definitely may not achieve most of these.

The learning process that creates and sustains lasting impression is the one that identifies and focuses on the skills and traits that lead to effective self-management (High Reach Learning, 2007). Learners hold expectancies and these expectancies are mental representations which influence behaviour (Mbah, 2003; High Reach Learning, 2007). Based on past outcomes and the situation they now confront, the learners' judgment of the likelihood of getting their desired outcome is therefore influenced. Thus, their expectancy judgments have a causal influence on their behavioural choices. Mbah (2003) notes, as do most social learning theorists, that if there is a link between behaviour and reinforcers, then behaviour is affected by the reinforcers. But if there is no link, then there will be less predictable reaction to reinforcers and, in the case of students, learning is not likely to occur, resulting in low achievement. The key to an individual's personal development is to understand one's natural tendency and then adapt it to the situations he is faced with. For a desired achievement in studies to occur, a student should accept responsibility of his effort and the outcome of his performance. This will encourage him to work harder when necessary (Mbah, 2003). This analogy encapsulates the need for the students to be helped to make their textbooks their closest friend. Gail (2009) emphasizing this importance of textbook reading, encourages teachers thus: '…if our students can't read the textbook, we as teachers are doing a disservice in not helping them to read. After all, first, they learn to read, and thereafter, they read to learn. We have to help them read and understand textbooks; otherwise we haven't done our job''.

The topics in Chemistry curriculum are organized and arranged based on identified academic needs of the students which form the bases for the major objectives. Learning should, therefore, be planned to achieve them. But the common practice has always been students depending on the teacher's limited knowledge and information on these topics. Should the teacher be the dogmatic and lazy type that keeps using his/her age-long note since graduation, the students will then be subjected to knowledge starvation and obscurity resulting in the designed objectives not being achieved. TwA aims to encourage students to study their textbooks for up-to-date information that will expand their knowledge horizon, sharpen their question-answering skills and improve performance. This approach entails that the teacher will dominate his lesson plan with activity-based steps, textbook references, short answer questions and exercises to ensure students' unflinching compliance to the achievement of the above concept.

Part of the aim of designing the TwA approach is to re-inculcate the academic discipline and the reading culture which have almost disappeared from the life pattern of the students, in particular and the youths, in general. This is because textbooks are indispensable companion and guide to teachers and learners; to teachers, in achieving and accomplishing their noble role as facilitators of knowledge. This role makes them only a guide to the direction of knowledge. To the students, the full text of what a student requires to know is discovered by the student through additional search in textbooks and other knowledge sources. All subjects are textbook-based and at least one textbook is required for each subject. A well-written textbook can help a student gain an overview of a lot of materials and often relates the subject to other relevant areas for better learning to take place (Osokoya, 1998). So, this learning approach, Textbook-with-Assessment, aims to whip up and accelerate the interest of the students towards the noble habit of reading textual materials. When Romack (2006) introduced the textbook-reading approach to his students which he termed "Readiness Concept", he recorded remarkable improvement in the students' performance. Also, Ryan (2008) presents some values and benefits expected to be enjoyed by the students when they study their textbooks, especially before lesson:

i. What happens during class makes much more sense.
ii. Students will have a deeper understanding of key concepts and that makes it easier for them to integrate those concepts into their own lives.
iii. They learn the difference between informed and uninformed discussion.
iv. When students have read the material before class, discussions in class are richer and more fun, not just for the teacher but for the students as well.
v. Coming to class prepared and with some background knowledge transforms students from passive to active learners.
vi. They will stop doing stenography and start doing the kind of critical thinking that promotes learning.

The assessment aspect of the approach is like a checks-and-balances measure. The items are well-articulated easy-to-answer questions or exercises to ensure that the student actually read the text.

The predominant instructional method in most schools is the conventional teaching methods-lecture and occasional demonstration in some cases because of the experimental nature of Chemistry. The teacher is always the controller of the learning environment. Power and responsibility are held by him and he plays the role of instructor and decision maker. By this method, students are seen as having 'knowledge holes' that need to be filled with information. In fact, to the conventional method, it is the teacher that causes learning to occur (Novak, 1998). However, the method is not completely bad neither is it being advocated for relegation nor outright discarded. As a matter of fact, most of these new approaches still use the conventional method at one point or other as new strategies develop. But, the quest for a more student-centred and result-oriented learning strategy, is to maximize the learning opportunities and diversify their benefits concealed in the learning outcomes.

Success in education is a combination of so many factors coming into play at some levels. The student, who takes the central position in the entire process of education, has his/her own part to play so as to achieve. However, he needs the support of other stakeholders in education to provide the enabling environment. So, Opportunity to Learn (OTL), which, in this context, is referred to as the equitable conditions and circumstances in the school and classroom that promote learning for all students, had to be controlled. It includes facilities (human and material), curriculum, and so on; all combined to enable students achieve high standards. Although learning can occur outside the school, daily observations have proved that the school is a place specifically and specially prepared for human learning facilitation. Research is unanimous in identifying the heuristic value of the school. It is clear that the school constitutes the necessary physical factors affecting human learning, which is OTL.

On the issue of curriculum, Stevens (1993) opines that the opportunity to learn designated curriculum for a grade level or all age group is a major equity issue for students who are at risk of not developing academically to their fullest potential. She emphasizes the teacher's role in determining OTL by implementing instructional models and programmes that will promote access to learning for poor and minority students. In connection to assessment, Winfield (1987) and Osokoya (1998) note that OTL relates to the provision of adequate and timely instruction of specific content and skills prior to the period the students would be tested or examined. The teacher should ensure sufficient coverage of the scheme of work and also ensure that test items are prepared within the level of content coverage. One of the treatment variables in this study includes assessment in addition to OTL, while school and classroom facilities were also focused. The adequacy of facility availability and the judicious handling of the curriculum actually needed attention due to the peculiar nature and delicate position of unity colleges in the determination of educational standard in the country.

In Nigeria, there are two categories of schools same sex (single-sex) school and coeducational (mixed) school. These categories or arrangements may have effect on learning outcomes because there might be some characteristic behaviour exhibited by students in same-sex school that may not be prominent in a coeducational set-up and vice versa. The influence of gender is always considered important in the process of learning and has been proved by various studies to be a strong predictor of human behaviour (Onuebunwa, 2000; Mbah, 2003 and Tatarinceva, 2005). Attitudes, behaviours and achievements of males and females most times differ towards different subject areas or fields of study (Obanya, 1984; Adeagbo, 2004; Adeyinka, 2005).Various studies have been carried out to ascertain whether there are disparity in the academic performance and behaviours of students in single-sex school and those in coeducational school settings. Do these set-ups significantly count when it comes to gender disparity and academic performance? The Australian Council for Educational Research (ACER, 2000) compared performance of students at single-sex and coeducational schools. Their analysis demonstrated that both boys and girls who were educated in single-sex classrooms scored higher than boys and girls in coeducational settings. The report also documented that "boys and girls in single-sex schools were more likely to be better behaved and to find learning more enjoyable and the curriculum more relevant." The concluding report also includes this: "Evidence suggests that coeducational settings are limited by their capacity to accommodate the large differences in cognitive, social and developmental growth rates of boys and girls aged between 12 and 16."

Furthermore, some critics argue that single-sex public schools attract children from more affluent families. These critics suggest that the superior performance of students in single-sex schools may be due to the higher socioeconomic class from which such students are purportedly recruited, rather than the single-sex character of the school itself. However, both the ACER study in Australia just mentioned and some other research bodies in Britain and America found no evidence to support that hypothesis (Riordan, 1998 and Dean, 1998). All the same, these studies went beyond just finding out the disparity in performance between students in single-sex school and coeducational schools. They also found out which of the genders is favoured and why.

There seems, therefore, to be some peculiar challenges inherent in same-sex educational set-up that do not occur in a coeducational set-up, which are capable of affecting learning outcomes. How evident are these in the chosen schools? It is with this background that the place of school type in Chemistry education, as defined above, was not overlooked in this study.

Students' learning outcomes are rapidly taking the stage as the principal determinant of educational effectiveness. But it does not seem as if many studies have delved into the impact of the learning outcomes in the areas of cognition and psychomotor. Ruhland & Brewer (2001) opine that learning outcomes should not only demonstrate what students know, but should also capture the changes that occur in their cognitive as well as their psychomotor development as a result of their school experiences. Bankole (2007) observes that good and positive personal or general orientation has long been accepted to be a distinct asset in academic achievement. A student's orientation is described as his acquired acts of getting information or knowledge. The nature and study of Chemistry place high demand on the student as the principal actor. How well he/she plays this role will eventually, directly or indirectly affect his achievement in Chemistry. In spite of their varying degrees of deficiency in learning, if the students are made to realize that what is desired of them as Chemistry students or problem-solvers by the NPE (2004) and other stakeholders in education is not only passing Chemistry in SSCE, but also turning out to be good, self-reliant and confident problem-solvers, they will most likely work to meet this target. This can be described as learning outcomes.

Academic achievement and manipulative ability are generally measured by assessing student's performance. These two indicators cover the cognitive and psychomotor domains of learning (Blooms, 1974). Cognitive growth begins at the level of infant school and continues to dominate education to the secondary and higher levels. With this acquisition goes a growing power to generalize, abstract, interpret, apply and create. Cognitive training produces the modes of thought and judgment that make up human intellectual activity. On the other hand, in the development of psychomotor learning, the teacher is concerned with the promotion of coordinated skills and their creative use (Mbah, 2003). These traits cannot easily be achieved using only conventional instructional methods or the lecture method which are teacher-centred; more learner-centred approaches are required. This prompted this study.

1.2 Statement of the Problem

Objectives of Chemistry learning are not only to ensure the acquisition of relevant knowledge, skill, and problem-solving abilities. They also include inculcating in the learners academic discipline and manipulative skills towards solving daily life problems. Such laudable objectives do not easily reflect positively in the enrolment and performance of students in Chemistry. This may be due to the fact that achievement in Chemistry and science, in general, is often times looked at from only the product point of view, whereas, it should be perceived in terms of the input, process and then product.

Although different approaches have been put forward by different researchers to increase enrolment and students' achievement in Chemistry, not much improvement is noticed. Obviously, students appreciate one another's company through playing, chatting and different levels of discussion on any issue of life. It is in this spirit of inculcating problem solving abilities that problem-based learning approach was applied in this study, stressing learning of Chemistry in group and focusing on specific problems relating to life and daily living for better understanding and achievement in Chemistry. Also, it has been observed that students do not like reading textual materials. In order to develop reading ability in them, this study also examined the effect of Textbook-with-Assessment on students' learning outcomes.

Therefore, the study sought to determine the effects of problem-based and textbook-with-assessment approaches on learning outcomes in secondary school Chemistry in Federal Government Colleges, South-West Nigeria. The investigation also ascertained the roles of opportunity to learn and school type in this regard.

1.3 Research Questions

This research provided answers to the following questions:

1. What are the pretest and posttest mean scores of students' academic achievement in Chemistry based on

a. Treatment

b. OTL

c. School Type

2. What are the mean differences in pretest and posttest scores of students' manipulative skills in Chemistry practical (practical skills in Chemistry) by

   a. Treatment

   b. OTL

   c. School Type

1.4 Hypotheses

The following null hypotheses were tested.

1. There is no significant main effect of treatment on students'
   (i) Academic achievement in Chemistry
   (ii) Manipulative skills in Chemistry practical (practical skills in Chemistry)
2. There is no significant main effect of opportunity to learn on students'
   (i) Academic achievement in Chemistry
   (ii) Manipulative skills in Chemistry practical (practical skills in Chemistry)
3. There is no significant main effect of school type on students'
   (i) Academic achievement in Chemistry
   (ii) Manipulative skills in Chemistry practical (practical skills in Chemistry)
4. There is no significant interaction effect of treatment and opportunity to learn on students'
   (i) Academic achievement in Chemistry
   (ii) Manipulative skills in Chemistry practical (practical skills in Chemistry)
5. There is no significant interaction effect of treatment and school type on students'
   (i) Academic achievement in Chemistry
   (ii) Manipulative skills in Chemistry practical (practical skills in Chemistry)
6. There is no significant interaction effect of opportunity to learn and school type on students'
   (i) Academic achievement in Chemistry
   (ii) Manipulative skills in Chemistry practical (practical skills in Chemistry)

7. There is no significant interaction effect of treatment, opportunity to learn and school type on students'

(i) Academic achievement in Chemistry

(ii) Manipulative skills in Chemistry practical (practical skills in Chemistry).

1.5 Scope of the Study

The study was carried out on senior secondary school two (SS2) Chemistry students from eight unity colleges in south-west education zone in Nigeria. The study was also limited to the effects of problem-based and textbook-with-assessment approaches and the combination of the two on SS2 students' Chemistry learning outcomes, (cognitive and manipulative skills).

1.6 Significance of the Study

The result of this study was meant to discover which method better promoted effective teaching and learning of Chemistry in senior secondary schools. The efficacious method(s) should then be adopted by the Chemistry students, teachers, and schools management as more interesting, rewarding, practical and solution-oriented methods. The outcomes of this study should also motivate curriculum designers and planners as well as other specialists in education to adopt the use of these methods in the learning of Chemistry for better performance, thereby attracting more students into the study of science and technology.

This study should also provide and furnish the Federal Ministry of Education and other relevant parastatals, such as the Nigerian Educational Research and Development Council (NERDC), West African Examinations Council (WAEC) and National Examinations Council (NECO), with required information on this innovation in Chemistry learning. It could also generate interest in publishing a new book to capture the new learning approaches. It is hoped that the result of the study has the capability to motivate the improvement of science and technology and its consequent technological emancipation that Nigeria as a developing nation so direly needs.

1.7 Operational Definitions of Terms

The following terms are operationally defined to reveal the meaning they portray in the study:

- Problem-based Learning: This is an approach used to acquire knowledge in which finding solution to a problem or a need-to-know topic is the motivating factor for the acquisition of the new knowledge.
- Textbook-with-Assessment Learning: It is an approach in which the textbook pages and figures of the topic to be studied are quoted in the lesson plan, while short-answer questions on the topic are needed to be answered as learning progresses.
- School Type: This refers to the gender make-up of the students in the school, vis; single-sex (all-boys, all-girls) and mixed school (both boys and girls).
- Learning approach: This is the method used in this research to get across and acquire knowledge of the topics taught vis; water and purification methods, IUPAC nomenclature and Electrolysis.
- Opportunity to learn: This is the expected quality and quantity of facilities, adequacy of curriculum content and lesson-time allocation that will accord the students high standard achievement in Chemistry.
- Treatment refers to the learning approaches manipulated in the teaching of Chemistry in this study, vis; PB, TwA, and PB and TwA, approaches.
- Learning outcomes are the results of the anticipated responses from students after being exposed to the treatments in this study.
- Conventional method is the way of teaching commonly used in the sampled schools for the teaching of Chemistry. They function as control measures to enable the researcher discover the effect of the treatment applied in the teaching of Chemistry in this study.

1.8 Conceptual Definitions of Terms

Approach: To deal with something in a particular way.

Coeducation: This is education of both male and female students together.

Single-sex education: A learning arrangement of either male or female students separately.

1.9 Abbreviations/Acronyms

NERDC--Nigerian Educational Research and Development Council

OTL--Opportunity to Learn

NPE--National Policy on Education

PBL--Problem-based Learning

TwA--Textbook with Assessment learning

IUPAC--International Union of Pure and Applied Chemistry

NFER--National Foundation for Educational Research

ACER--Australian Council for Educational Research

ANCOVA--Analysis of Covariance

OFSTED--British Office for Standards in Education

BSCS--Biological Science Curriculum Study

CHAPTER TWO
LITERATURE REVIEW

Related literature was reviewed in the following areas:

1. Theoretical framework.
2. The strategic position of Chemistry among the sciences and in everyday life.
3. The need to reposition Chemistry teaching and learning for national development and technological breakthrough.
4. Functional approach to teaching and learning of science as an instrument for change.
5. Problem-based learning approach and students' achievement
6. Textbook-with-assessment learning approach and students' achievement
7. School type and the learning of Chemistry.
8. Opportunity to learn and the study of Chemistry in secondary schools.
9. Appraisal of the literature reviewed.

2.1 Theoretical Background

The learning of science, especially Chemistry, in a meaningful way remains one of the overriding objectives of Chemistry teaching, and should be the main focus of attention of researchers. With new knowledge accumulating at an accelerating rate in the areas of Chemistry, new and viable approaches to Chemistry learning and instruction become imperative.

There is a growing consensus that science learning/instruction, as currently practiced leaves much to be desired in terms of students' understanding of science phenomena. This is more pronounced with science learning/instruction still showing a disappointing picture of predominant emphasis on memorization of facts and little success in increasing public understanding of science (Stake & Easley 1978; James, 1999).

Ausubel (1968) states that meaningful learning can only take place when a people consciously and explicitly ties new knowledge with relevant concepts or propositions they already possess or are able to discover in the process of trying to solve a problem.

This provides evidence that the individual has been able to internalize a new stimulus and it reflects in the ability to apply the new knowledge to other situations. In contrast, memorization, which mostly characterizes the traditional lecture method of teaching, results when new knowledge is arbitrarily incorporated into the cognitive structure.

Supporting the above view is the theory of Constructivism on which this study is based. It adopts the philosophy of learning that proposes that learners need to build their own understanding of new ideas and describes how learning takes place on the basis of the previous experience of the learner and the effort to understand instruction. It bases its assumption also on the belief that human capability of learning is at the centre of all teaching and learning processes and views learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past experience. The Biological Science Curriculum Study (BSCS), a team whose principal investigator was Roger Bybee, developed an instructional model in support for constructivism, called the "Five Es" (Miami Museum of Science 2001).

This approach as it relates to science learning can be summarized as follows: Learning something new, or attempting to understand something familiar in greater depth, is not a linear process. In trying to make sense of things, we use both our prior experience and the first-hand knowledge gained from new explorations. Using the problem-based learning approach to solve problem, as we begin to investigate new ideas, we can put together bits and pieces of prior explorations that seem to fit our understanding of the phenomena under investigation. Sometimes when the pieces do not fit together, there may be need to break down old ideas and reconstruct them. Sometimes, conceptual understanding may be extended through discussions and creative efforts and so validating theories to solve problems. The clarity gained in understanding a concept provides the ability to apply this understanding to new situations and new mysteries. It is a continuous and a very individual process.

Learners bring to each learning experience their developmental levels, personal story and personal style. It is up to the teacher to facilitate the constructivist learning process to accommodate all these behavioural traits. The structure of the learning environment should promote opportunities and events that encourage and support the building of understanding through textual materials and problem-solving skills.

A convenient format to view constructivism, as defined by Biological Science Curriculum Study (BSCS) model of five "E"s (Engage, Explore, Explain, Elaborate and Evaluate) is:

Engage: Here, the students first encounter and identify the instructional task from a problem situation. They make connections between past and present learning experiences, lay the organizational ground work for the activities ahead and stimulate their involvement in the anticipation of these activities. Asking questions, defining the problem, showing a surprising event and acting out a problematic situation are all ways to engage students and focus them on the instructional tasks.

Explore: In the Exploration stage, the students have the opportunity to get directly involved with phenomena and materials. Involving themselves in these activities, they develop a grounding of experience with the phenomenon. As they work together in teams, students build a base of common experience, which assists them in the process of sharing and communicating. The teacher acts as a facilitator, providing materials and guiding the students' focus. The students' inquiry process and determination to find solutions to the problem at hand drives the instruction during an exploration.

Explain: The third stage, Explain, is the point at which the learner begins to put the abstract experience through which she/he has gone into a communicable form. Language provides motivation for sequencing events into a logical format. Communication occurs between peers, the facilitator, or within the learner himself. Working in groups, learners support each other's understanding as they articulate their observations, ideas, questions and hypotheses. Language provides a tool of communicable labels. These labels, applied to elements of abstract exploration, give the learner a means of sharing these explorations. Explanations from the facilitator can provide names that correspond to historical and standard language, for student findings and events. For example a student, through his/her exploration, may state that they have noticed that a magnet has a tendency to "stick" to a certain metallic object. The facilitator, in her discussion with the student, might at this stage introduce terminology referring to "an attracting force". Introducing labels, after the student has had a direct experience, is far more meaningful than before that experience. The experiential base he/she has built offers the student an attachment place for the label. Common language enhances the sharing and communication between facilitator and students. The facilitator can determine levels of understanding of textual materials and possible misconceptions.

Elaborate: This stage allows the students to expand on the concepts they have read and learned, make connections to other related concepts, and apply their understanding to the world around them. For example, while exploring light phenomena, a learner constructs an understanding of the path light travels through space. Examining a lamp post, he may notice that the shadow of the post changes its location as the day grows later. This observation can lead to further inquiry as to possible connections between the shadow's changing location and the changes in direction of the light source, the sun. Applications to real-world events, such as where to plant flowers so that they receive sunlight most of the day, or how to prop up a beach umbrella for shade from the sun, are both extensions and applications of the concept that light travels in a straight path which they may have read in their science textbook but could not readily relate it to everyday living. These connections often lead to further inquiry and new understanding.

Evaluate: This last "E", Evaluate, is an ongoing diagnostic process that allows the teacher to determine if the learner has attained understanding of concepts and knowledge. Evaluation and assessment can occur at all points along the continuum of the instructional process. Some of the tools that assist in this diagnostic process are rubrics (quantified and prioritized outcome expectations) determined hand-in-hand with the lesson design, teacher observation structured by checklists, student interviews, portfolios designed with specific purposes, project and problem-based learning products, and embedded assessments. Concrete evidence of the learning proceed is most valuable in communications between students, teachers, parents and administrators. Displays of attainment and progress enhance understanding for all parties involved in the educational process, and can become jumping-off points for further enrichment of the students' education. These evidences of learning serve to guide the teacher in further lesson planning and may signal the need for modification and change of direction. For example, if a teacher perceives clear evidence of misconception, then he/she can revisit the concept to enhance clearer understanding. If the students show profound interest in a branching direction of inquiry, the teacher can consider refocusing the investigation to take advantage of this high level of interest. Viewing the evaluation process as a continuous one gives the constructivist philosophy a kind of cyclical structure.

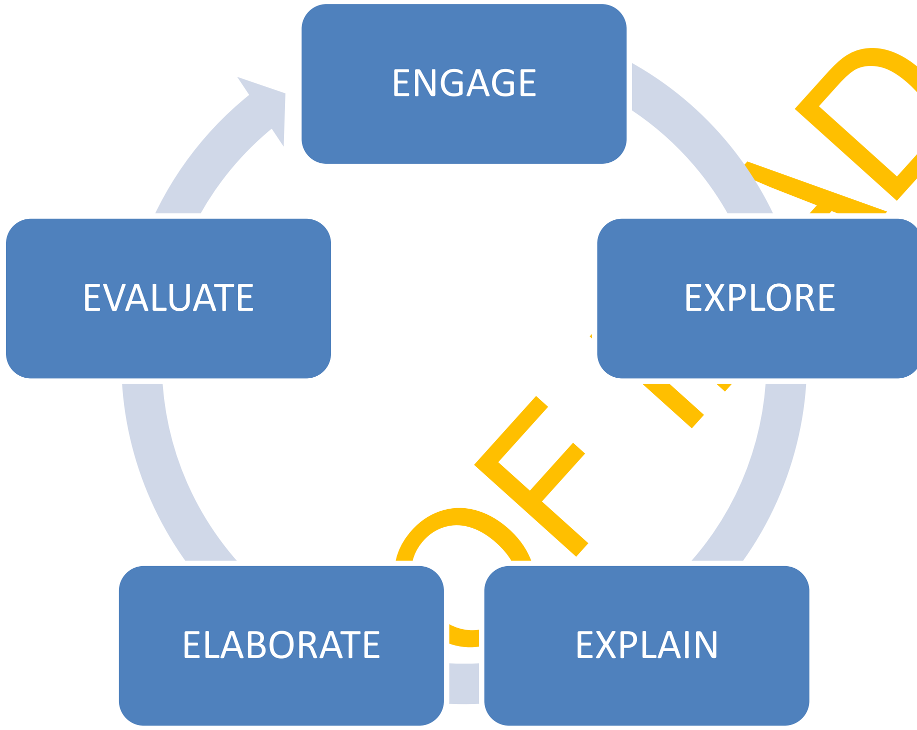

Figure 2: Structure of BSCS Model of Five 'Es

Much has been researched and written by many eminent scholars in the fields of learning theory and cognition. Scholars such as Jean Piaget (1952), Vygotsky (1989), and VonGlasersfield (1991), stressed the importance of the learner being actively involved in the learning process unlike the traditional educational view point where the responsibility rests on the teacher while the student becomes a passive listener. Also, the naturalistic theorists made useful contributions to further explain the education of a child as an unfolding process. The child develops inevitably as a product of nature, and the main function of the teacher is to provide the optimum condition for this development. This leads to the theory that the child's experience is the essential thing. A Swiss educator, Pestalozzi, was a leading theorist in this field. His practical schemes were designed to provide the most appropriate experience for the child's development. In a way, the modern revival of potency of experience is an acknowledgement of the developmental element in learning (Mbah, 2003).

Jean Jacques Rousseau (1962) also started from the assumption that man conforms to nature. He assumed the certainty of spontaneous development of powers and faculties, and urged that any form of constraint was to be avoided. He saw a man as a noble savage growing in isolation in nature. But nature also means a social life. Rousseau's views are therefore summerised thus;

- a reduced emphasis on knowing and a greater emphasis on acting and doing
- a promotion of positive interest on learning, and
- an encouragement of the child to depend on his own resources

Summerising the above, Mbah (2003) affirms that naturalistic theories are clearly inadequate in the modern world of science and technology, but their emphasis on spontaneous child activity, as opposed to excessive formal instruction, is a valuable component of the educational process. This study also shares the view.

2.2 The Strategic Position of Chemistry among the Sciences and in Everyday Life

Science and technology are the bedrock on which development is built and sustained. According to Bajah (1982), 'science at whatever level is the subject best able to train the mind to the use of its own power'. Scientists and science educators view science as a dynamic body of knowledge, still seeking new knowledge as well as a way of explaining events and phenomena in nature (Adeola, 2000). Chemistry is described by a renowned author of Chemistry texts, Ababio (1990), as a branch of pure science which deals with the composition, properties and uses of matter. It probes into the principles governing the changes that matter undergoes. It also includes man's attempt to transform the natural world in order to benefit from nature's complexities and hidden resources. Okeke and Ezekannagha (2000) define Chemistry as a branch of science that deals with the composition and changes of matter. Ezekannagha and Ifeakor (2002) note that, Chemistry is a very fundamental subject that investigates the basic properties of substances in the physical universe. In fact, Chemistry has a very strategic and central position among the sciences because almost all the other branches of science borrow some knowledge from Chemistry to interpret their principles, for examples, Biochemistry, Physical Chemistry, Medicinal Chemistry, Geochemistry and Pharmaceutical Chemistry. The experimental nature of Chemistry as a science subject makes it almost indispensible to science learning as it affects every aspect of life and living. It has also been stated that Chemistry provides enough opportunity for students and teachers to learn, unlearn and relearn, to become productive thinkers (Tofler, 1970). The study of Chemistry is full of activities and this enhances the acquisition of certain skills and competences which can make an individual become scientifically literate, self-adaptive and productive (Ezeasor, 2003).

Chemistry has enabled scientists to discover the usefulness of matter in its three states--gases, liquids and solids, Also, the study of chemical structure of matter has made it possible for manufacturers to produce essential materials, like drugs, papers, dyes, cloths, cream, soaps, tonics and assorted brands of wine which are very useful to man, (Nwosu, 2002). The importance of Chemistry to mankind has long been recognised and appreciated. Ezekannagha and Ifeakor (2002) state that Chemistry seeks to serve man in as many human endeavours as possible, be it at home, in agriculture, in industry and in medicine.

Chemistry at Home: Man wakes up every morning with Chemistry, because the tooth-paste used in brushing teeth is a mixture of soluble inorganic salts and the brush is made of nylon which is also a synthetic chemical product. The toilet paper is produced from wood, the washing and toilet soaps are products of saponification process of fats, oil and alkali. The water is a product of Oxygen and Hydrogen. If the source of water is not reliable for both drinking and other domestic uses, chlorination, filtration and sedimentation, which are all chemical processes, are applied. Fermentation of sugar and carbohydrate-based raw materials yields alcohol for all alcoholic drinks. Ascorbic acid and citric acid from unripe fruits and citrus fruits, acetic acid from vinegar and so on, all have sour taste because of the acid they contain. Milk of magnesia, chemically known as magnesium hydroxide, is a base and it is used to treat the problem of excess stomach acid (Okonjo, 2005). The cooking of the food we eat is a chemical transformation of the substances in food items to a more suitable form for human consumption. The list is inexhaustible because the house we live in was built with cement, sand and water; the roof, whether aluminum, zinc or asbestos, are all familiar Chemistry materials (Ezekannagha and Ifeakor, 2002).

Chemistry in Agriculture: In agriculture, Ezekannagha and Ifeakor (2002) state that Chemistry provides fundamental bases upon which the technology for production, processing and preservation of food is established. Analysis, classification and treatment of soils to increase their fertility are taken care of under analytical Chemistry and through the provision of mineral fertilizers, such as ammonium tetraoxosulphate (VI), ammonium tetraoxophosphate (V) and ammonium trioxonitrate (V). Also, herbicides, pesticides, chemical preservatives and additives contribute greatly to the great successes recorded in agriculture and agricultural products that made it possible for man to feed the ever-growing population. Ezekannagha and Ifeakor (2002) reported the documentation in World Book Encyclopedia, vol. 7, which revealed that for plants to produce food, they need about nine chemical elements, namely; carbon, hydrogen, oxygen, phosphorous, potassium, nitrogen, sulphur, calcium and magnesium. These plants also must need smaller amounts of several other elements in little quantities called “micro nutrients”, some of which are boron, copper, zinc, iron, manganese and molybdenum; all these are chemical elements. For any nation to be self-sufficient in food production, it must definitely need agricultural chemicals which are all Chemistry-based.

Chemistry in Industry and others:

Petroleum industry is another area in which the knowledge of Chemistry is very necessary and prospering. For instance, in cracking, distillation, separation, extraction and chemical analysis of petroleum products, different types of fuels and other petrochemicals, like polyethene for making household plastics, are all evidences of knowledge of Chemistry and its industrial contribution to life (Akuezeilo, 1993). Stressing the importance of Chemistry and chemical personnel, Ikoku (1982) suggests that the country should produce on continuing basis, the requisite number of chemists, chemical engineers, chemical laboratory technologists and technicians adequately trained and appropriately oriented to assume the responsibility of creating a viable chemical industry as well as supplying the chemical expertise required by other industries.

Textile industries are not left out as one of the largest consumers of chemicals. As Ezekannagha and Ifeakor (2002) put it , virtually all the basic processes in textile goods production are chemical processes, such as sizing, desizing, scouring, bleaching, washing, dyeing, printing and finishing. Also, large quantities of caustic alkalis, dyestuff, acids, sulphides, peroxides and so on, are all raw materials indispensably needed in the textile industry.

In bottling companies, the gaseous preservatives used, like carbon (IV) oxide and hydrogen, are all chemicals. In sachet and bottle water factories as well as alcohol manufacturing companies, the major principle is distillation. The list is endless.

2.3 The Need to Reposition Chemistry Teaching and Learning for National Development and Technological Breakthrough

Education is considered globally as the most important instrument of change and development (Odetokun, 2005).That Nigeria, like other developing countries, needs it desperately for her citizens cannot be overlooked if she must catch up with or at least close up a bit the wide gap that exists between her rate of development and that of developed nations. This goal may be faster achieved through greater and adequate support to science and technology education. The global goal of science education is not only to increase the quality and quantity of information but also to create possibilities for the learner to invent and discover (Ogunmade and Taiwo, 2002; Eze, 2004; Olabisi, 2006). This move is geared towards producing problem--solvers who will become analytic, critical, productive, rational and reflective thinkers. Akinola (2007) affirms that science educators and other concerned individuals have been expressing concern over the perennial problems in the teaching and learning of science in Nigerian secondary schools because of the importance of science in the development of any nation. Science is taught in schools in various branches such as Physics, Chemistry, Biology, Agricultural Science, Health Science, Integrated (Basic) Science, and Mathematics. Each of the branches requires different but specific approaches that require different teaching and learning resources (Nwosu, 2002). Considering the importance of Chemistry in all round development, Etukudo, Udobia and Nnaobi (2002) emphasize that there is need to make sure that Chemistry is properly taught. This emphasis was based on their focus on mathematical skill as a catalyst in the teaching and learning of Chemistry for sustainable development. It has been discovered that lack of requisite mathematical skill would make it impossible to produce critical thinkers and problem-solvers for adequate and sustainable technological development. Harbor-Peters (2000) asserts that the culture of Mathematics has afforded many people the opportunity of knowing and assessing things in the environment that they would not have been able to without Mathematics. This was possible because of the problem-solving skills ignited from scientific reasoning acquired from Mathematics.

2.4 Functional Approach to Teaching and Learning of Science as an Instrument for Change

To facilitate sustainable science education, the high rate of changes in the modern society needs to be filtered and preserved. Therefore, functional education is a prerequisite which will metamorphose into meaningful development. This would be further highlighted by interdisciplinary approaches to science teaching and learning (Hofstein & Mamlok, 2001).

Chemistry is not as abstract or difficult as it is viewed or portrayed. The crux of the matter is the method of conveying the knowledge. For over half a century now, great progress has been made in the development of Chemistry teaching. Chemical education curricula have metamorphosed into having been organized around the processes of scientific inquiry and mastery as well as the unifying conceptual ideas (Jegede, 2003). As a result, memorization of information has to give way to comprehension and application of chemical information. Depth rather than breadth and investigatory rather than confirmatory exercises are emphasized in the study of Chemistry (Eze, 2002). This view has the support and backing of the reforms in WAEC Chemistry syllabus in which it is specified that Chemistry teaching should focus on the following broad aims:

i. To stress principles and unifying concepts of Chemistry without demanding memorization by the students of a vast amount of factual information, and

ii. To develop skills in investigating problems based on an understanding of practical work.

Despite the above-stated broad aims, most Chemistry teachers in Nigerian secondary schools still employ “talk and chalk” or “lecture method” only, or with little demonstration, in the teaching of Chemistry which is deficient in promoting learning but enhances rote learning. Complementarily, test and examination questions are drafted to portray their method of teaching. This scenario brings to the fore the statement made years back by William (1976) concerning Chemistry teaching in African universities. He notes that, “Chemistry, like Mathematics and Physics, has less African context than most subjects, the form in which it is being taught is of vital concern.’’ …. the African child has learned almost all he knows by rote, for this is the way in which he was taught to learn and this was the way in which examinations were passed”. Chemistry has no cultural barrier; it is the way teachers of the subject present chemical information that leaves much to be desired, (Bello, 2005). For meaningful and quality achievement to be recorded by Chemistry students, which will extend to societal development and human thinking pattern, instructional strategy must change to more practical and problem-solving-approach.

2.5 Problem-Based Learning Approach and Students' Achievement

Origin of Problem-Based Learning Approach

Problem-based learning (PB), in its most current form, originated from Medical Education but has since been used in a variety of disciplines, at a variety of educational levels (Savery & Duffy, 1995; Savery, 2006). Briefly, PB is characterized as an approach to learning in which students are:

i. Given more control over their learning than a traditional approach,
ii. Asked to work in small groups, and
iii. Most importantly, likely to acquire new knowledge only as a necessary step in solving authentic, ill-structured, and cross-disciplinary problems representative of professional practice (Barrows & Tamblyn, 1980; Barrows, 1986, 1996, 2002;).

This approach to learning arose, in part, from a sharp contrast between experiences at the beginning and end of medical school. During the first two years, students were put off by learning vast amounts of factual information, unsure of its connection to their future practice. During their residency, however, they tended to be highly motivated while engaging with patients and their problems (Spaulding, 1969). This was because the students could relate and apply the knowledge they had acquired throughout the period of their training in the medical school to the reality of the patients' health problems.

Problem Based Learning (PB) implementations were put forward by Barrows (1986) through a learning taxonomy. The taxonomy moved from lecture-based cases to closed-loop problem based learning and includes a claim that the closed-loop approach is best positioned to enhance some educational objectives. It seems logical to expect that this type of PB learning implementation might play a positive role in learning outcomes. An area of interest to achieve this is a focus on the problem types with which students are engaged. Jonassen (2000) proposed a typology of problems (ranging from logical problems to dilemmas) that includes associated learning activities, inputs, success criteria, context, and abstractness. Problem types may prove even more important than the examination of work done to acquire learning by the implementing body. According to Barrows (1996), PB learning has taken on a myriad of definitions pushed in part by institutions which desire to refine their particular approach. This is true to an even greater extent with PB learning expanding to several different disciplines and contexts outside medicine and education.

Changes to PB learning as initiated by institutions to reflect their needs and the needs of their discipline have made it somewhat difficult to construct a clear statement about what is and what is not PB learning. With that caveat in mind, and borrowing heavily from Barrows as one of the initial proponents of PB learning, some components can be considered appropriate in relation to this study. PB learning is:

i. Problems presented as unresolved so that students will generate not just multiple thoughts about the cause of the problem, but multiple thoughts on how to solve it (Barrows, 2002). Such problems may not have a single correct answer and should engage students in the exploration of multiple solution paths.

ii. A student centred approach in which students determine what they need to learn based on what is on their scheme and areas they need help. It is up to the learners to derive the key issues of the problems they face, define their knowledge gaps, and pursue and acquire the missing knowledge (Barrows, 2002; Hmelo-Silver & Barrows, 2006).

iii. Teachers are facilitators or tutors in the learning process. These facilitators, initially prompt students with meta-cognitive questions and, in subsequent sessions, fade that guidance (Barrows, 2002). They forgo lecturing about content in favour of modelling the kinds of learning processes that lead to success in PB settings (Hmelo-Silver & Barrows, 2006).Such learning processes may include monitoring the class activities to ensure that the entire class is carried along, encouraging contributions from members, and ensuring that the students' thought patterns are in the direction of the expected behavioural objectives.

These and more components constitute the minimum standards of PB learning.

Problem-Based Learning and achievement

Problem Based (PB) learning is an approach connecting real-life problems or challenges to the classroom and modifying classroom activities to meeting daily life needs of the students and those of the environment. The problem drives learning on a 'need to know' basis (Akoh, 2004). The discovery of what to know in order to solve a problem has to be made first; then, learning is organized to meet the need. It can be individual or group-based, self-directed, student-directed or teacher-guided. Using modelling examples based on screen recordings from participants in problem-solving conditions, Osman (2008) shows that goal-free effect applies to such learning as well. The goal-free effect has been studied in cognitive load research with problem-solving tasks (Sweller and Levine, 1982; Ayres, 1993; Paas et al, 2001). It shows that learning is enhanced when students are not provided with a specific goal during problem-solving. Providing students with no or a non-specific goal is assumed to prevent the use of means-ends analysis, thereby leading to better learning. Apparently, this benefit applies not only to the performer, but also to the observer's learning (Ayres & Paas, 2007;.Osman, 2008).

On the other hand and as the case may be, problems are absolutely essential for problem-based learning to prosper. This school of thought believes that problems initiate students' learning in PB learning. In other words, if there are no problems, there will be no problem-based learning. Although there are plenty of real-life problems around us, identifying the suitable problem to guide and direct students in their learning can be challenging.

How should a problem for PB learning be designed? Is there any specific style or pattern to adopt? Should there be any interesting article/case study that is relevant to learning objectives to pose relevant questions? Or should learning objectives be identified and questions be posted on them? Is there a systematic way of designing these problems? Recent studies suggest that problem effectiveness could be defined by eleven characteristics which are categorized into:

i. features characteristics, and

ii. functions characteristics.

Features characteristics are designed elements while function characteristics are the desired outcomes of the problems Nachamma (2011). In designing problems, the characteristics to be manipulated are the feature characteristics which are;

- problem clarity,
- problem format,
- problem difficulty level,
- problem familiarity and
- problem relevance

On the other hand, the function characteristic is the extent to which problem:

- Leads to the intended learning issues,
- Promotes self-directed learning,
- Stimulates critical reasoning,
- Stimulates elaboration,
- Promotes team work and
- Triggers interest.

In order to incorporate all these and make them relevant and realistic in designing effective problems in PB learning, Nachamma (2011) suggests that one could start off with analyzing students' characteristics and learning needs which will shed light on their prior knowledge and familiar content/context (these will cover information on problem familiarity, difficulty and relevance); their learning style (which will provide information on problem format) and comprehension capabilities (which will provide information on problem clarity). Such information needs to be incorporated into the presentation of the problem (Entwistle and Tait, 1990; Doyle 1997; Elen and Lowyck, 1999). This layer of the problem design could be likened to the user interface of the problem. Underlying the user interface is the content. Problem designers would need to identify the learning issues that need to be focused on and tailor it to students' prior knowledge and learning needs. Hence it is essential to first analyse students' characteristics and learning needs to develop problems. This content then needs to be framed in a relevant and realistic context that students can relate to and apply in their studies and daily life (Olajide, 2005).

In addition to user interface, and the content, one needs to also focus on what is expected from the students as a result of working on the problem. This will create a platform on which to assess the achievement or outcomes at the end of the intervention.

Ko¨nings, van Merrienboer, and Brand-Gruwel (2010) opine that how students perceive instruction determines the nature and quality of their learning processes. Instruction does not influence learning directly, but students' perceptions of instruction influence learning and study behaviour and eventually learning outcomes (Doyle, 1977; Entwistle and Tai, 1990; Elen and Lowyck, 1999). Additionally, students tend to stick to learning preferences and habits and only use those elements of instruction that are in line with their habitual way of learning (Vermetten, Vermunt, and Lodewijks, 2002). It is, therefore, important to know how students perceive their instruction; to what degree is different aspects of instruction, such as student autonomy, are observed to be present in a course by the students. However, Watkins, (2004) and Holt, Denny, Capps, and de Vore (2005) affirm that students' perceptions and desires, with regard to their instruction, should be made more explicit, since those perceptions and desires appear to have a direct effect on learning processes. Since student autonomy is a component of the PB approach, it will be an action in the right direction if the approach is given a trial to see its effect on their overall learning achievement.

2.6 Textbook-with-Assessment Learning Approach and Achievement

One of the research findings of the factors that influence students' achievement in schools is inadequate or lack of use of textbooks by students. Osokoya (1998), while highlighting the importance of textbook, suggests that a curriculum development team which includes scientists, researchers and educators, produces curricular materials such as textbooks. Quoting Lynch et al (1963), she notes that school science textbooks have always played a major role in shaping what science is taught and indeed how it is taught. Put in another way and emphasizing this importance of textbook, Osokoya (1998) and Okonkwo (2004) state that the textbook presents and represents the intentions of curriculum developers in which they stated the knowledge content for each subject and the class. A well-written textbook can help a student gain an overview of a lot of materials and it often relates a subject to other relevant areas. When reading textbooks, a lot of valuable knowledge is being acquired and stored unconsciously in the brain which can easily be recalled and used appropriately. Sandra (2001) observes that the community-based project forced me to apply those lessons learned in the textbook and it proved to be valuable learning experiences indeed'. Heyneman, (1983) quoted in Osokoya (1998), claims that higher learning achievement is associated with availability of textbooks and other printed materials.

But a more serious problem is how the students will be made to read or rather study these textbooks even when they are made available. Something has to be done to arrest the situation because the consequences are increasing by the hour through undeniable display of ignorance by school graduates at all levels. The cause for the alarm is, if they cannot read novels, magazines and other less cognitive print materials, reading their textbooks, which will demand a higher level concentration, will definitely be an uphill task. This is a problem indeed. This researcher, therefore, decided to attach assessment to the use of textbook as a check to ensure compliance to the mandate of the teacher to make the students learn from their textbooks. The assessment simply means asking few questions or/and giving small exercises from the topic or the passage in the textbook in such a way that the student must read the passage to get those questions or exercises done. It is also intended that some of the questions asked will be part of the final examination questions to further motivate the students to use their textbooks.

The effect of the poor reading culture got so bad that many concerned Nigerians and corporate bodies are beginning to wage war against it. Radio Nigeria for instance has run several news commentaries on the dangers of this cankerworm. The National Library of Nigeria has also placed an advert on radio portraying some advantages of reading. Some television programmes, like 'Who wants to be a millionaire', primary and secondary schools debate and quiz competitions, all aim to instill a better reading culture in the youths, but not much progress has been recorded.

Furthermore, the General Overseer of Mountain of Fire and Miracles Ministries, Dr D.K. Olukoya, in an attempt to encourage members of the ministry in the area of improving their reading habit, commenced a monthly book quiz in July 2010. People of any age group are to read two recommended books every month. On the last Sunday of that month a written quiz is organized for as many people that read the books and want to participate in the quiz. Fantastic prices, ranging from free books to brand-new laptop computers, LG flat screen televisions, Microwave ovens, BlackBerry hand set, as well as cash prizes in foreign currency, are given to as many that got the highest scores after marking and compiling the scores by the organizers. About two and a half years of running this programme, the response has increased from less than two hundred participants in 2010 to an average of eight hundred participants in the December 2012 edition. It has also been discovered that more than one thousand percent increase of readers has been observed even though they never participated in the quiz. By this result, it is hoped that if more effort is applied in this fight to improve reading culture in the youths by more individuals and corporate organisations, probably attaching some material gains, in addition to academic excellence, more success may be recorded in future.

2.7 Opportunity to Learn (OTL) and Chemistry Learning

Education is a strong factor in people's ability to develop self and their environment. (Chukwuka, 2006). It is a major catalyst or propelling force towards national development; technologically, scientifically, socially and so on. In a developing country like Nigeria, the importance of education cannot be ignored. Fundamentally, every government owes its citizens quality education and should ensure that all stakeholders perform their civic duty towards its success for empowerment of the youths. Schwartz (1995) states that, common sense dictates that, in order for students to achieve, they must have appropriate opportunities to learn. Since then, some additional criteria have been incorporated into the concept, such as to ensure equal education for disadvantaged and minority students, as a standard to be met in an attempt to providing educational services and as indicators of educational quality (Schwartz, 1995). These criteria were categorized into three, viz:

i. OTL as a measurement tool
ii. OTL as a set of standards, and
iii. OTL as assessment;

OTL as a Measurement Tool

The original purpose of OTL measures, when introduced, was simply to describe aspects of the education process. To determine whether cross-national differences in students' Mathematics achievement were caused by differences in students' learning experiences rather than in their ability to master the subject, International Association for the Evaluation of Educational Achievement (IEA), which was the investigating body, developed measures for quantifying the instruction which the students had received in a subject prior to testing (McDonnel, 1995). This has showed an important contribution of OTL strategies to education because they could now be used to indicate overall educational quality, especially the availability and use of educational resources. From this, OTL measurable indicators could be developed to measure the effectiveness of government-funded education programmes, which cover both classroom experience and the overall school environment.

OTL as a Set of Standards

Education policy makers believe that setting OTL standards will help schools to appreciate their relevance to educational infrastructure and make developing them a priority. Government and private schools would be made to equip and develop their schools to meet the set standards outside which their licenses could be withdrawn or revoked. OTL standards are necessary because they could help to close the achievement gap between advantaged and disadvantaged students.

OTL as Assessment

When OTL in a school is evaluated, it will provide information on whether the school has adequate resources, deploying them effectively and providing equal education across the learners. The Ministry of Education, which is the organ of government responsible for providing the curriculum materials for the teaching of Chemistry and other subjects, should ensure workable and adequate curriculum materials. This is because it is a well-known fact that the nature of classroom transaction is strongly dependent on the curriculum materials used, since these materials, to a large extent, determine the opportunity to learn offered to the students (Onu, 2007).

In a study which focused on the manner in which Senior Secondary students learn about controlling variables, a concept fundamental both to science and everyday decision-making, Bowyer et al (1978), quoted in Onu (2007), state that children have the opportunity to learn through a wide range of carefully designed science activities and materials from which they freely choose. A situation where materials available are only the demonstration copy which the teacher alone handles to show to the students how it is used or operated has not provided adequate opportunity to learn to the students.

Chemistry is a practical-oriented subject. The aims and objectives for practical work are structured under five main headings:

i. Understanding concepts,
ii. Acquiring habits and capacities,
iii. Gaining skills,
iv. Appreciating the nature of science, and
v. Developing attitudes.

According to Ezeliora, (2002) and Onu, (2007) these objectives can only be realized if students are provided with the opportunity to be involved in the necessary experiences. Active participation in laboratory activities should stimulate a synthesis of ideas and the development of critical and analytical skills that are difficult to develop through individual effort. Since a single practical class encompasses several concepts and principles, it helps students to better understand theory and provoke diversified thinking and reasoning, which are what society needs for sustainable development (Ezekannagha and Ifeakor, 2002; Ezeliora, 2002; Onu, 2007).

Another important component of the curriculum which calls for urgent attention is time allocation. The time apportioned for teaching certain subjects, especially Mathematics and the sciences matter, a lot. From personal experiences and observations, Chemistry learning and classroom transactions that take place from about 1pm usually does not receive high percentage attention (concentration) from the students. Some of them would either be tired or restless, thereby showing divided attention and haphazard involvement. The nature of Chemistry as a science subject requires that full attention be given by all concerned for any meaningful learning to take place. Very few students have the intellectual ability to cope with the learning of any subject at any period of the day, but they are always handful compared to the class population. Every learner should be exposed to equal learning conditions, so as to have standard performance assessment at the end of each learning exercise or activity. Time allocation for lessons should be done with consideration of the nature of the subjects in question. This makes it pertinent that OTL should be controlled in this study.

2.8 School Type and the Learning of Chemistry

Students not only differ in gender, age and cultural background but also in learning styles. The issue of gender differences in achievement still needs the attention of researchers. Elliot (1991) and Godwa & Griggs (1995) produced scientific evidence which showed females and males to be equally intellectually capable, but Ebel (1999); Grebb (1999) and Cavanaugh (2002) found that they learn differently from each other. Consequently, the influence of gender is always considered important in the process of learning (Tatarinceva, 2007). So, the issue of school type, as we have in this study, is of two categories, namely; single-sex (all boys, all girls) and coeducational (mixed) schools. Does this grouping in any way affect learning, positively or negatively? MacDonard (2002) observes critically male and female children to find out what could be the disparity in the way they perform academically. He discovered that both sexes perform well at the elementary level until age 13 when girls begin to slip gradually behind till secondary level when they exhibit more negative performance than boys. When these boys and girls are now together in a class, will they likely influence each other in a coeducational category in Chemistry learning or are they going to perform better in a single-sex setting?

The National Foundation for Educational Research (NFER) was commissioned to study the effect of school size and school type [single-sex vs. coeducational (coed)] on academic performance. The Foundation studied 2,954 high schools throughout England, where single-sex public high schools were widely available. The summary of their report goes thus:

Even after controlling students' academic ability and other background factors, both girls and boys did significantly better in single-sex schools than in coeducational schools. In this age group (senior high school), the benefits were larger and more consistent across the board for girls than for boys. Specifically, girls at all levels of academic ability did better in single-sex schools than in coeducational schools; whereas for boys, the beneficial effect of single-sex schools was significant only for boys at the lower end of the ability scale. For higher-achieving boys, there was no statistically significant effect of school type on performance, positive or negative.

Girls at single-sex schools were more likely to take non-traditional courses--courses which run against gender stereotypes--such as Advanced Mathematics and Physics. The researchers concluded that girls' schools were "helping to counter rather than reinforce the distinctions between 'girls' subjects' such as English and foreign languages and 'boys' subjects' such as Physics and Computer science". No such effect was seen for boys: for example, boys at single-sex schools were no more likely (actually somewhat less likely) to take courses in cooking than were boys at coed schools (NFER, 2002).

The above research findings in England not only showed that there is disparity in the academic performance of students in single-sex school and coeducational school, but it also specifically states that girls are better favoured than boys in single-sex school than in coeducational school setting. However, the report reveals that boys at the lower ability scale benefitted immensely by the single-sex school setting than in the coeducational, which helped to solve the academic need of that category of boys.

In another development, the Australian Council for Educational Research (ACER) compared performance of students at single-sex and coeducational schools. Their analysis, based on six years of study of over 270,000 students, in 53 academic subjects, demonstrated that both boys and girls who were educated in single-sex classrooms scored on average 15 to 22 percentile ranks higher than boys and girls in coeducational settings. The report also documents that "boys and girls in single-sex schools are more likely to be better behaved and to find learning more enjoyable and the curriculum more relevant." The report concludes that: "Evidence suggests that coeducational settings are limited by their capacity to accommodate the large differences in cognitive, social and development growth rates of boys and girls aged between 12 and 16."

Some critics argue that single-sex public schools attract children from more affluent families. These critics suggest that the superior performance of students in single-sex schools may be due to the higher socioeconomic class from which such students are purportedly recruited, rather than the single-sex character of the school itself. However, both the ACER study in Australia just mentioned, and the Foundation study, both found no evidence to support this hypothesis.

Dean (1998) reports the research findings of Cornelius Riordan, which claims that girls who attend single-sex Catholic schools typically come from a lower socioeconomic background than girls who attend coeducational Catholic schools. Also, in 1998, the British Office for Standards in Education (OFSTED) put this to test, that is, whether socioeconomic variables might account for the superior performance of students in single-sex schools. They examined test results from 800 public schools, single-sex and coeducational. OFSTED found that the superior performance of students in single-sex schools cannot be accounted for by socioeconomic factors, but appears, instead, to be a direct result of single-sex education. They also found that the students in single-sex schools had a significantly more positive attitude toward learning (ACER, 2000 and OFSTED, 1998).These disparities in the performances of students in the two school settings are gender-focused.

The studies in Mathematics carried out by Hacket and Beta (1989) and Eissenberg, Mattin & Fabes (1996) show that gender difference tends to favour male students. In the language arts, many researchers claim that girls are more favoured (Pajares and Valiante, 1997; Pajares, Miller & Johnson, 1999; Ogundare, 2005). Will Chemistry, a science subject with mathematical ideology, to an extent show the same gender disparity in performance as stated above? Tyagi (2007) observes that female students had a significantly higher attribute of feeling preference than their male counterparts for whom thinking attribute was higher. This trait is an advantage for Mathematics and science-related students. Therefore, students' learning styles can be influenced by gender. But from the report of NFER (2002), single-sex school setting characteristics can counter these ideologies.

Cavanaugh (2002) found that boys tend to be kinesthetic and visual and, so, need more mobility in a more informal environment than girls. Boys are more peer-motivated and non-conforming in approach to learning. This is why a group of truants may decide to sneak out of class to the obscure part of the school compound and be playing football during lesson hours. Marcus (1999) and Pizzo (2000) opine that females are more auditory-oriented, self-and-authority-motivated, and significantly more quiet while learning than males. Conversely, Jegede and Inyang (1990) discovered in their studies that boys performed better than girls in Integrated Sciences probably because of their mobility nature. Butler (2000) and Chanlin (2001) state that there are gender differences in academic achievement.

These studies, however, failed to clarify the school type or class arrangement (single-sex or coeducational setting) under which their research was carried out. Able (2000) notes that the unsubstantiated mythology of the educational establishment has been that girls do better in single-sex schools but that boys are 'brought on' by the more studious girls in a coeducational environment. Another yet-to-be-proved educational myth in support of coeducation says that boys do better in the classroom if girls are present to set them a good example. Here again the subject area being handled was not stated. There is, therefore, an urgent need for a research proof in these areas. Chemistry learning is not much different from learning of those other subjects cited in the reviewed studies. So, this study finds it relevant to control the two categories of gender arrangement of the schools in the study.

2.9 Appraisal of the Literature Reviewed

There is a growing consensus that science learning/instruction, as currently practised leaves much to be desired in terms of students' understanding of science phenomena. This is more pronounced with science learning/instruction still showing a disappointing picture of predominant emphasis on memorization of facts and little success in increasing practical application and public understanding of science (Stake & Easley, 1978; Jegede, 2007). The learning of science, especially Chemistry, in a meaningful and practical way remains one of the overriding objectives of Chemistry teaching, and is one of the main focus of attention of this and some other researchers.

With new knowledge accumulating at an accelerating rate in the area of Chemistry, new and viable approaches to Chemistry learning and instruction are imperative.

Scholars have stressed the need for the identification of an approach that would bridge the gap between experimental psychology of learning and practical needs of meaningful teaching and learning. They opine that, when a people consciously and explicitly ties new knowledge with relevant concepts or propositions, they already possess or are able to discover in the process of trying to solve a problem or from studying textual materials, then learning has been internalized (Smith and Smith, 1966; Ausubel,1968 and Maxwell, 2006). This ideology is based on the theory of constructivism, which is the philosophy of learning that proposes that learners need to build their own understanding of new ideas on the basis of the previous experience. An instructional model called the "Five Es"-(Engage, Explore, Explain, Elaborate and Evaluate) is a convenient format to view constructivism as defined by Biological Science Curriculum Study (BSCS) (Miami Museum of Science, 2001).

Because education is considered globally as the most important instrument of change and development, using the problem-based learning approach to solve problem acknowledges the fact that learners bring to each learning experience their developmental levels and experiences, personal story and personal style. It is up to the teacher to facilitate this constructivist learning process to accommodate all these bevavioural traits in order to get the learner actively involved in the learning process (Ogunmade & Taiwo, 2002; Eze,2004; Odetokun, 2005; Olabisi, 2006;). This move is geared towards producing problem-solvers who will become analytic, critical, productive, rational and reflective thinkers, who will implement the required change expected in the learning process and achievement (Etukudo, 2002; Nwosu, 2002; Akinola, 2007). To facilitate sustainable science education, the high rate of changes in our modern society today needs to be filtered and preserved. Functional education is a prerequisite which will metamorphose unto meaningful development. This would be highlighted by interdisciplinary approaches to science teaching and learning (Hofstein & Mamlok, 2001).

Chemistry is not as abstract or difficult as it is viewed or portrayed. Most literature reviewed discovered that Chemistry has no cultural barrier. It is the way teachers of the subject present chemical information that leaves much to be desired (Bello, 2005). So, the main crux of the matter is the method of conveying the knowledge. Chemical education curriculum has metamorphosed into being organized around the processes of scientific inquiry and mastery as well as the unifying conceptual ideas. As a result, memorization of information has to give way to comprehension and application of chemical information. Depth rather than breadth and investigatory rather than confirmatory exercises are emphasized in the study of Chemistry (Bello, 2003). For meaningful and quality achievement to be recorded by Chemistry students, which will produce societal development and human thinking pattern, instructional strategy must change to more textbook-based, practical and problem-solving approaches.

Science and technology are the bedrock on which development is built and sustained. Most of the studies reviewed see science, Chemistry, in particular, as occupying a strategic position in enhancing national development and technological breakthrough in everyday life. Chemistry is a subject best able to train the mind to the use of its own power. In fact, Chemistry is often described as the Queen of the Sciences because almost all the other branches of science borrow some knowledge from Chemistry to interpret their principles, for example, Biochemistry, Physical Chemistry, Medicinal Chemistry, Geochemistry and Pharmaceutical Chemistry. The experimental nature of Chemistry as a science subject makes it almost indispensable to science learning as it affects every aspect of life and living by its discoveries. The importance of Chemistry to mankind has long been recognised and appreciated, as it seeks to serve man in many human endeavours, be it at home, in agriculture, in industry and in medicine (Bajah, 1982; Ababio, 1990; Akuezeilo, 1993; Adeola, 2000; Okeke and Ezekannagha,2000; Ezekannagha and Ifeakor, 2002; Ezeasor, 2003)

The studies reviewed, claim that problem-based (PB) learning originated from Medical Education but has since been used in a variety of disciplines and educational levels (Savery & Duffy, 1995; Savery, 2006). PB learning is characterized as an approach to learning in which students are given more control over their learning than in a traditional approach, asked to work in small groups and most importantly, likely to acquire new knowledge only as a necessary step in solving authentic, ill-structured, and cross-disciplinary problems. Its components as considered appropriate in relation to this study are: problems presented as unresolved, student centredness and teacher as facilitator (Barrows & Tamblyn, 1980; Barrows, 2002, 1996, 1986; Hmelo-Silver & Barrows, 2006; Savery, 2006). These components portray PB learning as a viable learning strategy, connecting real-life problems or challenges to the classroom and modifying classroom activities to meeting daily life needs of the students and those of the environment. In fact, it is the problem that drives learning on a 'need to know' basis. The discovery of what to know in order to solve a problem has to be made first; then, learning is organized to meet the need. The studies reviewed also showed that learning is enhanced when students are not provided with a specific goal during problem-solving. As they source for the solution to the problem at hand, it becomes imperative for them to consult textbooks and other information and education materials. This concerted effort will lead to self-discovery, which internalizes learning (Sweller and Levine, 1982; Ayres,1993; Paas et al,2001; Akoh, 2004; Osman, 2008).

Research findings on the importance of textbook, generally acknowledge the fact that students do not read as they should. A curriculum development team, which usually includes scientists, researchers and educators, produces curricular materials, including textbooks, which help in shaping what science is taught and how it is taught. They discovered that when reading textbooks, a lot of valuable knowledge is being acquired and stored unconsciously in the brain, which can easily be recalled and used appropriately. This is referred to as a higher learning achievement associated with availability of textbooks and other printed materials (Osokoya, 1998; Sandra, 2001; Okonkwo, 2004). But the problem is how to make the students read or rather study these textbooks even when available in order to improve their performance. This is a problem indeed. So, this researcher, introducing textbook-with-assessment (TwA) learning approach, decided to attach assessment to the use of textbook as a check to ensure compliance to the mandate of the teacher to make the students learn from their textbooks. Schwartz (1995) opines that for students to achieve, they must have appropriate opportunities to learn. Opportunity to learn as a measurement tool, a set of standards and as an assessment instrument, is necessary for learning achievement. The Ministry of Education, which is the organ of government responsible for providing the curriculum materials for the teaching of Chemistry and other subjects, should ensure workable and adequate curriculum materials, since these materials greatly determine the opportunity to learn offered to the students (Ezeliora 2002; Ezekannagha and Ifeakor 2002;Onu 2007).

There is no gainsaying the fact that gender-wise, students influence each other in learning styles. The issue of gender differences in achievement still needs the attention of researchers. Elliot (1991), Godwa & Griggs (1995), and MacDonard (2002), from the result of their investigations produce scientific evidences which show females and males to be equally intellectually capable, but Ebel (1999), Grebb (1999), and Cavanaugh (2002) found that they learn differently from each other. Consequently, the influence of gender is always considered important in the process of learning (Tatarinceva, 2007). So, the issues of school type, single-sex and coeducational schools, in this study, need to be controlled accepting that Chemistry learning is not much different from learning of those other subjects in the school curriculum.

In summary, therefore, one of the benefits of education is to improve the life of the learner and his/her environment. So, there should be proper understanding of the subject in question, firm grip of the concept desired and willingness to confidently apply the knowledge in every challenging situations he/she would face. The gap discovered from the literature, the proposal of new strategies supported by some educational theories and the acknowledgement of the need to control for certain moderating variables were the driving force for this study.

CHAPTER THREE
METHODOLOGY

This chapter describes the research methodology, which includes research design, target population, sampling techniques and sample, instrumentation, data collection and data analysis procedures.

3.1 Research Design

The study used a 4 x 3 x 2 randomized pre-test and post-test, control group, quasi-experimental design. The layout of the design is shown as below:

Experimental group1 – O_1 X_1 O_2

Experimental group 2 - O_1 X_2 O_2

Experimental group 3- O_1 X_3 O_2

Control group - O_1 X_4 O_2

Where;

$O_{1=}$represents pre-test academic achievement in Chemistry as well as manipulative skills in Chemistry practical.

$O_{2=}$ represents post-test achievement in Chemistry as well as manipulative skills in Chemistry practical.

X_1=represents problem-based approach which was the treatment on group one

X_2=represents textbook-with-assessment approach which was the treatment on group two.

X_3=represents problem-based and textbook-with-assessment approaches together which was the treatment on group three.

X_4=represents conventional method which was used on group four –the control group.

3.2 Factorial design

Table 3.1: Showing 4 x 3 x 2 factorial design

Treatment	Opportunity to Learn			School Type	
	Low	Moderate	High		
Problem-based Approach				Single-sexed	
				Co-educational	
Textbook-with-assessment approach				Single-sexed	
				Co-educational	
Problem-based and Textbook-with-assessment approach				Single-sexed	
				Co-educational	
Conventional method of teaching/learning				Single-sexed	
				Co-educational	

3.3 Variables in the Study

The following variables were involved in the study:

Independent variables: Treatment operated at four levels;

- ✓ Problem-based approach
- ✓ Textbook-with-assessment approach
- ✓ Problem-based approach and textbook-with-assessment approach
- ✓ Conventional method (control)

Moderator variables: The moderator variables controlled in the course of this study were;

- ❖ Opportunity to learn
- ❖ School type (category)

Dependent variables: These were the learning outcomes expected from the learners at the end of the study:

- ➢ Academic achievement in Chemistry
- ➢ Manipulative skills in Chemistry practical(Practical skills in Chemistry)

3.4 Population

The target population for this study comprised:

1. SS2 Chemistry students in eight (8) unity colleges in the South-Western Zone of Nigeria.
2. Eight (8) Chemistry teachers
3. Eight (8) laboratory attendants
4. Seven (7) proctors

3.5 Sampling Techniques and Sample

The purposive sampling technique was adopted for this experimental study: Three states--Lagos, Ogun and Oyo, out of the six in the zone, were purposively selected because of the high concentration of unity colleges in these states, eight in all. They also possessed the required characteristics (single-sex and coeducational) needed for their inclusion. Eight schools in the selected states were used and grouped into two categories of single-sex and coeducational colleges. One Chemistry intact class was randomly selected in each of the schools and treatment was also randomly assigned.

3.6 Instruments

The researcher developed and validated three instruments used for collection of data and four treatment manuals for treatment. These instruments were:

- Chemistry Achievement Test (CHEMAT)-For pre-test and post-test: Appendix 1
- Chemistry Manipulative Skills Scale (CHEMMSS) – For pre-test and post-test: Appendix II
- Students' Questionnaire for the Assessment of Opportunity to Learn (SQAOTL): Appendix III
- The treatment manuals called Chemistry Treatment Manual (CHEMTM) were introduced : Appendices IVa, IVb, IVc
  - Treatment Manual of Instruction on Problem-based Learning Approach. (TMIPBLA): Appendix Va

- Treatment Manual of Instruction on Textbook-with-Assessment Learning Approach (TMITLA): Appendix Vb
- Treatment Manual of Instruction on Problem-based and Textbook-with-Assessment Learning Approach (TMIPTLA): Appendix Vc
- Treatment Manual of Instruction on Conventional Method of Teaching (TMICMT): Appendix Vd

3.6.1 Chemistry Achievement Test (CHEMAT)

This instrument was designed by the researcher to measure acquisition of knowledge in selected topics in SS2 Chemistry before and after treatments had taken place. It was made up of two sections. Section A consisted of students' personal profile, such as name of school, class, sex and age. Section B was a 50- item multiple choice tests with four options A-D. Students were required to pick the correct option from the alternatives provided. The items were constructed from the Chemistry topics picked from SS2 third term scheme of work which was confirmed to be common to all the selected schools for this study because they use the same syllabus. The validation of the items was done using 94 SS2 Chemistry students of Comprehensive Secondary School, Tafawa Balewa, Surulere, and Cleg Girls' Secondary School Surulere, both in Lagos. Kuder Richardson formula 21 was used to establish the reliability coefficient value of 0.78 for the instrument. The content validity was established using the table of specification drawn from the selected topics in the Chemistry syllabus and scheme of work being used in the unity colleges. This item specification was developed to reflect the first four cognitive domains of Bloom's taxonomy of educational objectives: Knowledge, Comprehension, Application and Analysis (Bloom, Madus and Hastings 1981). The questions in the instrument covered these cognitive levels because of the age and academic level of the study target group. The Chemistry teachers in the schools whose students were used for pilot testing and teachers from federal government colleges assisted in the moderation of the questions to ensure the items fall within their standard.

The items were also standardized using the Chemistry students of the above mentioned schools in Lagos to determine the difficulty and discrimination indices of the items. The final 35 questions used for the study were selected after rejecting very difficult and very easy items (values 0.1-0.3 and 0.75-1.0 difficulty indices respectively). The students were given thirty minutes to answer the questions. The table of specification for the final 35 items is shown below.

Table 3.2a: Table of specification for Chemistry achievement test (CHEMAT) before standardization:

Topic/Objectives	Knowledge	Comprehension	Application	Analysis	Total
Water	6(12%)	5(10%)	6(12%)	3(6%)	20(40%)
Electrolysis	5(10%)	4(8%)	6(12%)	3(6%)	18(36%)
IUPAC nomenclature	5(10%)	3(6%)	2(4%)	2(4%)	12(24%)
Total	16(32%)	12(24%)	14(28%)	8(16%)	50(100%)

Table 3.2b: Standardised Table of specification for Chemistry achievement test (CHEMAT):

Topic/Objectives	Knowledge	Comprehension	Application	Analysis	Total
Water	(6)17% 1,7,10,13,14, 15	(4)11% 2,11,12,16,	(4)11% 3,4,8,9	(2)6% 5,6,	(16)46%
Electrolysis	(3) 9% 20,22,28	(3)9% 17,18,26	(5)14% 19,21,24,27, 30	(3)9% 23,25,29	(14)40%
IUPAC nomenclature	(3)9% 32,34,35	(2)6% 31,33	Nil	Nil	(5)14%
Total	(12)34%	(10)29%	(8)23%	(5)14%	(35)100%

3.6.2 Chemistry Manipulative Skill Scale (CHEMMSS)

The researcher developed this instrument used to measure the knowledge and manipulative abilities of the students towards the use of basic Chemistry practical apparatus in the laboratory and understanding of the procedural steps required. The practical aspect of focus was Introduction to Volumetric Analysis according to SS2 scheme of work for the term. The proctors used the prepared 33-item scale to test the students. It is a 4-point Likert scale response options of Very good (VG), Good (G), Fairly Good (FG) and Fair (F). The skills were listed and value scores of 4-1, respectively, were apportioned or awarded for different levels of mastery by the research assistants. The face validity and content validity of the items were established by having them vetted by experienced Chemistry teachers and two knowledgeable evaluators in the Institute of Education, University of Ibadan. Further validation was done to ascertain the psychometric properties by trial testing it on the 94 students of Comprehensive Secondary School, Tafawa Balewa and Cleg Girls' Secondary School, both in Surulere, Lagos. Cronbach Alpha was used to establish the reliability coefficient value, which was 0.87, thereby ascertaining the internal consistency of the instrument.

3.6.3 Student Questionnaire for the Measurement of OTL (Moderator Variable) SQMOTL

The instrument was developed by the researcher to elicit information from the students that were used to measure the availability and adequacy of study and infrastructural materials and services. The standardized SQMOTL was made up of 31 (thirty-one) Likert scale items soliciting information on the quantity and quality of physical materials and human resources at the students' disposal that would enable them achieve excellence. The scale had four options: 'Strongly Agree' (SA), 'Agree' (A), 'Strongly Disagree' (SD) and 'Disagree' (D). Scores for each of the items ranged between 1 to 4. The psychometric properties of the instrument were ascertained by trial testing and validation using the 94 students of Comprehensive Secondary School, Tafawa Balewa, Surulere, and Cleg Girls' Secondary School Surulere, both in Lagos. Cronbach alpha was used to establish the reliability coefficient, which was 0.78. Having met the validity and reliability requirements, the internal consistency of the instrument was thereby ascertained.

3.7 Chemistry Treatment Manual (CHEMTM)

The researcher developed this manual that was used by the research assistants. It contained the selected topics from the scheme of work that was taught during the period covered by the research. This was meant to ensure conformity of depth of coverage. The categories for application of the instrument were: experimental group 1, exposed to problem-based approach; experimental group 2, exposed to textbook-with-assessment approach; the experimental group 3, exposed to the combination of problem-based and textbook-with-assessment approaches; then the control group was taught using the conventional method. The researcher played the role of the coordinator and the observer while the research assistants were the trained Chemistry teachers of the intact class randomly selected for treatment in the selected schools and the laboratory attendants. Another set of proctors were trained who specifically assisted in the administration of pre-and post- test manipulative skill test which required observations and scoring.

3.7.1 Treatment Manual of Instruction on Problem-Based Approach (TMIPBA)

This manual that was prepared by the researcher was to guide the teachers and the students on the various steps applied while using the problem-based approach. Since the focus was more on students' participation, the activities they performed were highlighted in an orderly manner and in a very explicit language. The TMIPBA was made up of two sections. Section A was the guide for the theory aspect and section B the guide for the practical aspect.

Section A

Teacher's activities;

The steps are as follows;

Teacher;

- ❖ Explains the principles of problem-based learning approach. (See Appendix 1Va).
- ❖ Randomly assigns the students into groups of five or six to form about seven or eight groups.
- ❖ Mentions the problem area to be handled in the day's lesson.
- ❖ Guides the students to mention the relevant Chemistry topic related to the problem at hand.
- ❖ Leads the students into the lesson properly as a facilitator.
- ❖ Allows the students to use their notes which they had from other related topics.

- Allows students about twenty minutes in their groups to make suggestions and contribute ideas towards solving the problem.
- Coordinates all contributions from the different groups through their leaders and extracted the relevant points.
- With a follow-up summary of the points raised, the students' note for the lesson was formed.
- Another problem is read out to students as take home assignment to brainstorm in their groups in readiness for next lesson or a short quiz to assess their levels of understanding of the topic.

Students' Activities:

Students;

- Read through the manual and ask any necessary question.
- Take note of the explanation on the concept of PB approach.
- Form their groups of five and choose their leaders.
- Mention the relevant Chemistry topic in their scheme related to the problem at hand as instructed by the teacher
- Brainstorm in their groups using their note from earlier lessons (where necessary) to suggest solutions.
- Group leaders coordinate the suggestions and contributions of their group members towards solving the problem, and present when called up to do so.
- Write down the summary note on the day's lesson and the take-home assignment where applicable.

Section B:

Joint activities for Practicals (teacher, lab attendants and students)

- The catalogue of students' weak areas as revealed by WAEC and NECO Chief Examiners' reports is read out in order to address the targeted problem.
- All reagents and apparatus for practicals are prepared, labelled and provided at the right time and in adequate quantities.
- Students maintain their groups and work there together.
- Written instruction of what the students are required to do (that is titration of acid and base) is displayed on the board or on a separate sheet of paper.
- Titration materials are made available supplied and collected.

- ❖ Teacher and the lab attendants go round to ensure that each group is carried along and there is order in the class/laboratory.
- ❖ Questions from students are answered and general corrections given.
- ❖ Submission, checking and scoring of students' practical notes is also done.

3.7.2 Treatment Manual of Instruction for Textbook-with-Assessment Learning Approach (TMITLA)

This manual was to give both the teachers and students the step-by-step direction on how to implement the textbook-with-assessment learning approach. The role of the teacher as a guide was explicitly highlighted and the activities of the students as the principal actors were also given for easy implementation.

The following are the steps:

Teacher's activities:

Teacher;

- ✓ Explains the principles of textbook-with-assessment learning approach (See Appendix 1Vb).
- ✓ Instructs the students to bring out their recommended textbooks (which they are suppose to have got from the beginning of the session as a requirement to register for Chemistry), ensuring that each student has at least one of the recommended texts in the class every day.
- ✓ Explains to the students how the approach will be implemented and makes them practicalise in class how pages (pp.), paragraphs (pgfs) and figures (figs) in the textbooks are used.
- ✓ Introduces the topic for the day's lesson.
- ✓ Briefly highlights the grey areas of the topic.
- ✓ Gives pages and paragraphs in textbooks that treat the topics under study.
- ✓ Releases the adjoining assessment questions and exercises.
- ✓ Treats the adjoining questions in class with the students as the lesson progresses.
- ✓ Gives more reading assignments for students to prepare for next lesson.

Students' activities:

- ✓ Read through the manual and react.
- ✓ Take note of the teacher's explanation of the concept of textbook-with-assessment approach and the procedure for use.
- ✓ Bring out their textbooks and do the paging, paragraphing and referencing with the teacher.
- ✓ Listen to the lesson introduction.
- ✓ Identify key areas of the topic.
- ✓ Adhere to further instructions from the teacher.
- ✓ Copy the assessment questions and exercises and attempt them.
- ✓ Ask questions on aspects where they need help.
- ✓ Take down the summary note formed from the assessment questions.

Joint Activities for Practical (teacher, lab attendants and students)

- ✓ Problems identified by WAEC and NECO Chief Examiners' reports concerning students' performance in Chemistry practical are read out.
- ✓ All reagents and apparatus for practical are prepared and labeled at the right time and in adequate quantities.
- ✓ Carry out a brief assessment of the knowledge of the students on the apparatus to be used for the titration exercise.
- ✓ Each student to show at least one practical textbook belonging to him/her.
- ✓ References of appropriate pages in the practical Chemistry textbook are given.
- ✓ Students read through and react.
- ✓ Teacher attends to students' questions on what they are expected to do during the practical.
- ✓ Students carry out the practical following the teacher's instructions for the day's titration.
- ✓ Teacher and the laboratory assistants coordinate the practicals by observing the students closely to ensure compliance to instructions.
- ✓ Questions from students are answered and general corrections given.
- ✓ Submission, checking and scoring of students' practical notes follows.

3.7.3 Treatment Manual of Instruction on Problem-Based and Textbook-with-Assessment Learning Approach (TMIPTLA)

Teacher's activities:

Teacher;

- Explains the principles of problem-based and textbook-with-assessment learning approach (See Appendix 1Vc).
- Explains how the approach is implemented and randomly assigns numbers 1-5 to distribute the students into groups.
- Presents the problem to be handled and agrees with the students the Chemistry topic related to it.
- Gives a brief explanation of what the topic is all about and the depth to cover.
- Lists the recommended textbooks for the students and directs that everyone should show his/her own.
- Teaches the students how to number paragraphs and figures for easy referencing.
- Releases questions and exercises that would guide the students in the right direction to get the solution for the existing problem while reading the textbook.
- The groups are asked to discuss and brainstorm on the problems using their textbooks and proffer solutions.
- Coordinates the class activities by maintaining orderliness and answering students' questions.
- General evaluation is done at the end of the lesson period by the teacher who coordinates all suggestions that makes up the students' note.
- Gives more reading home works and the accompanying assessment questions.

Students' Activities:

- Listen to the teacher's explanation of the principles and implementation of PB and TwA approaches.
- Take numbers, form groups and choose group leaders.

- With the help of the teacher, identify the problem to be tackled and Chemistry topic that could be used to solve the problem using the textbooks.
- Learn paragraph numbering for appropriate referencing (only on the first day of any new topic)
- Brainstorm in their groups, reading their textbooks along, at a time agreed by them outside lesson hours.
- Group leaders present their contributions in class during lesson.
- Copy the summary note from the discussions.
- Take more reading assignments and assessment questions.

Joint activities for Practical (teacher, lab attendants and students)

The practical are focused on introduction to volumetric analysis which is the aspect on SS2 scheme of work.

- Problems identified by WAEC and NECO Chief Examiners' reports concerning students' performance in Chemistry practical are read out.
- Reagents and apparatus for practical are prepared and provided at the right time in adequate quantities.
- Practical Chemistry textbook references having the step-by-step procedure for the practical are given.
- The practical are coordinated by the teacher and the laboratory assistants by observing the students work in their groups closely and constantly reminding them of the Chief Examiners' reports in order to effect and master the corrections needed and using their textbooks appropriately.
- Questions from students are answered and general corrections given.
- Students' practical notes are submitted for checking and scoring.

3.7.4 Treatment Manual of Instruction on Conventional Learning Approach (TMICLA)

The Conventional method is the prevailing and the traditional teaching/learning method known and commonly used by students and teachers. It involves lecture, talk and chalk, occasional demonstration because of the experimental nature of Chemistry, and students listening and watching. The following are the steps to follow:

Teacher's activities;

Teacher

- ❖ Asks questions on the previous lesson to establish understanding and create bases for the new topic.
- ❖ Diagnoses the missing gaps and provides further explanations.
- ❖ Introduces and develops the topic for the day and writes on the board as well.
- ❖ Note dictation accompanies the teaching.
- ❖ Gives oral or written quiz based on the topic taught for the day or home work to be submitted later.
- ❖ Scores the students' class work notes.

Students' activities

- ❖ Answer teacher's questions to display their level of understanding and ask any adjoining questions where applicable.
- ❖ Listen attentively.
- ❖ Copy the notes religiously, with or without asking the teacher any question till the end of the lesson.
- ❖ Do the class test or copy assignment.

Practical:

Practical lessons are not usually taken seriously until external examination is fast approaching. So, practical lesson periods are mostly theorizing the practical. But for the sake of this research and because it is on SS2 scheme of work, the researcher appealed that it should be done. Normally, in this approach, teacher does virtually everything while students watch.

Teacher's Activities in the Laboratory:

- ❖ Reminds the students of the list of apparatus given to them in SS1 to draw and learn.
- ❖ Introduces the volumetric analysis aspect of the practical they would do and write it on the board.

- ❖ Ensures that the laboratory assistants prepare and label all reagents and apparatus for practical at the right time and materials in adequate quantities.
- ❖ Narrates to the students what he does, that is, titration procedure till he gets the final titre value.
- ❖ The lab attendants are always at hand to assist.
- ❖ Collects the students' Chemistry practical notebooks for scoring.

3.8 Research procedure

The study lasted for a period of eight weeks.

1. The first two weeks were used for the training of research assistants, students' orientation and administering of pre-tests and Questionnaire
2. The remaining six weeks were used for the treatments, that is implementing the new approaches in the classroom, and for post-tests immediately after the treatments, using the developed instruments--CHEMAT and CHEMMSS

3.8.1 Training of participating research assistants

The training was organized to provide step-by-step explanations on the use of the treatment manuals and the learning guides for the treatments as well as the manipulative skill tests. Two weeks were used for these trainings. Necessary corrections and amendments were effected at this stage. This training was conducted by the researcher for the participants in their respective schools due to the distance among them, but the manipulative skill raters, who constituted the monitoring and implementing group of seven, were trained together to ensure inter-rater reliability obtained as 0.79 and uniformity of operation. The same pilot schools in Surulere, Lagos were used for this.

3.8.2 Students' Orientation and Administration of Pre-test

All the Chemistry students in the intact class of each study school were given an enlightenment briefing on what they were expected to do. During this time, students' operational manuals were distributed to them. This orientation took place on the second week during which the CHEMAT and CHEMMSS were administered as pre-tests to measure the knowledge levels of the students before treatment commenced. The questionnaire for the measurement of OTL was also administered.

3.9 Treatment Procedure

The Chemistry teacher of the intact class used and two laboratory assistants in each of the selected schools were trained and used as research assistants. The two laboratory attendants were trained to ensure that one was available at any point in time. They used the Chemistry treatment packages provided by the researcher. In addition, seven proctors were trained to assist the researcher for effective implementation and monitoring of the treatments.

PB, TwA, PB and TwA and Conventional method were used to teach the experimental as well as the control groups. During this period, students were taught some aspects of water, electrochemistry and IUPAC nomenclature under acids and bases by the trained teachers and the laboratory assistants in their various schools. The theory lessons for a double period of one hour twenty minutes a week lasted for five weeks. A double period of the same one hour twenty minutes was used for practical lessons for three weeks which took off from the fourth week of the project, after which both the theory and the practical ran concurrently. The theory ended on the fifth week, while the practical ended on the sixth week with posttest. The theory post-test was done on separate days within that sixth week. The practical lessons were based on the separate scheme for practical which centred on the introduction to volumetric analysis. This was handled also using the problem-based, textbook-with-assessment approaches, combination of problem-based and textbook-with-assessment approaches as well as the conventional method.

3.9.1 Problem-based Learning Approach (PB) – Experimental Group One

Enlightenment/orientation of students was done, to brief them on their expected classroom behavior, when problem-based approach was used. The chosen Chemistry topics for theory aspect of the treatments were covered using the problem-based approach for five weeks. The practical aspect of the treatment, which was introduction to volumetric analysis, was also covered within three weeks, using the same problem-based approach.

3.9.2 Textbook-with-Assessment Approach (TwA)–Experimental Group Two

Textbook-with-assessment is student-centred approach which aims to inculcate in and encourage the students in the habit of learning from their textbooks to excel and to develop good skills for reading and answering questions. Enlightenment on the students' expected classroom behaviour when TwA approach is used was done. The TwA approach was implemented during the learning of all the selected topics for the study period.

3.9.3 Problem-based and Textbook-with-assessment Approaches - Experimental Group Three

This approach involves the combined application of the two new approaches to see if together they would yield better learning. This approach was used on the same Chemistry topics both for theory and practical for the period of the treatment.

3.9.4 Conventional Method-Control Group

The conventional method is the prevailing and the traditional teaching/learning method known and commonly used by students and teachers. It acts as control measure to discover any effect of those treatments on the learning outcomes in Chemistry. As in earlier approaches, those Chemistry topics were treated using this method for the same period of six weeks. Pre and post-tests were also administered to the students at the beginning and the end of the treatment respectively.

3.10 Data Analysis

For this study, descriptive statistics was used to answer the research questions while the statistical tool used to establish the main effect and the interaction effect of the independent variable on the dependent variables was analysis of covariance (ANCOVA).

3.11 Methodological Challenges

There were a few challenging situations encountered during the treatment procedure. This research took off during the second quarter of third term. The teachers had already identified the aspects of the scheme of work that must be covered. So, coming to take the only double period they had for the week posed a great challenge. When they saw that the topics prepared for the treatment were some of the topics they meant to teach within the term, they welcomed. us but not without an assurance of incentives.

Also, one of the proctors could not complete the exercise owing to unforeseen circumstances. The researcher had to double as both an observer and proctor for the CHEMMSS. However, the population of the students in the concerned school was not high. So, the research assistants available were able to cope.

The researcher also battled attrition challenges on the side of the students. It was observed that some students who participated in the orientation exercise and took part in the pre-test and filling of the questionnaire were absent for the post-test, thereby reducing the sample size, but because the number involved was not high, the final population was still acceptable.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of the findings in this study. The presentation is according to the research questions and hypotheses stated. The study tested the stated hypotheses and interpreted findings at 0.05 level of significance,($p< 0.05$).

Research question one: What are the pretest and posttest mean scores of students' academic achievement in Chemistry based on

a. Treatment
b. OTL
c. School Type

4.1.1 Descriptive Statistics

This explains the pre-test and post-test mean scores of students' academic achievement and manipulative skills in Chemistry practical by treatment, opportunity to learn and school type.

Table 4.1: Summary of mean difference of students' academic achievement in Chemistry by treatment

Treatment	N	Pretest		Posttest		Mean Gain
		Mean	Standard Deviation	Mean	Standard Deviation	
Problem-based Learning	71	19.46	3.876	29.38	5.274	9.92
Text-book with assessment	69	20.65	4.646	25.64	4.643	4.99
Problem-based & Text book	88	22.03	4.647	27.97	6.052	5.94
Conventional method	53	23.47	5.060	25.06	4.789	1.59

As seen in Table 4.1 above, the students under problem-based (PB) instruction had the highest mean gain (9.92), followed by those under problem-based and textbook [PB & TwA] (5.94), textbook-with-assessment [TwA] (4.99) and conventional method

(1.59), in that order. This implies that students under problem-based group had the highest post-test score (X= 29.38), while those from control group had the least post-test mean score (25.06).

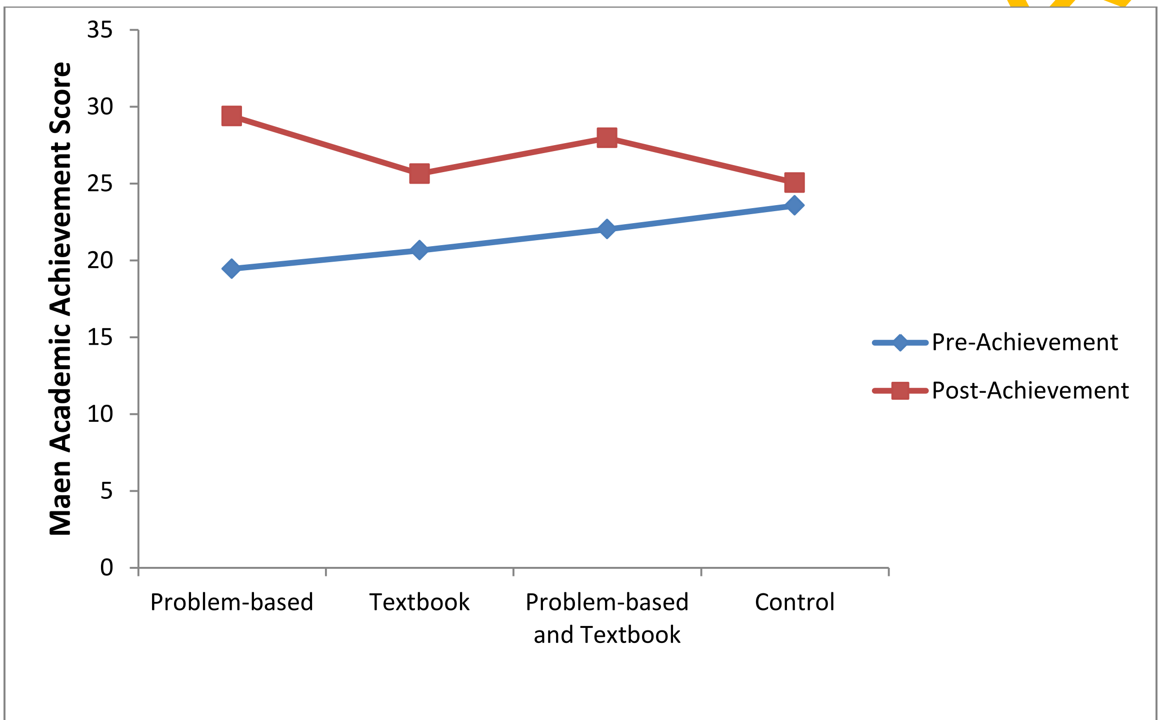

Figure 4.1: Pre-test and Post-test Academic Achievement Mean Scores by Treatment

Figure 4.1 shows that the post-test academic scores were higher than the corresponding pre-test scores of each treatment.

The results on Table 4.1 and Figure 4.1 showing higher post-test academic scores than pretest scores revealed that PB, TwA, and the combination of PB and TwA actually improved the students' performance in Chemistry. This was due to the fact that these approaches are student-centred. Students' full participation gave them better understanding which resulted in improved performance. PB having the highest mean score proved that when real life problem which the students could identify with, was used as a bases for treating a topic in Chemistry, they participated fully during the lessons and their performance was better.

Research Question Two: What are the mean differences in pretest and posttest scores of students' manipulative skills in practical Chemistry (Practical skills in Chemistry) by

a. Treatment
b. OTL
c. School Type

Table 4.2: Summary of mean difference of students' manipulative skills in Chemistry practical (Practical skills in Chemistry) by treatment

Treatment	N	Pretest		Posttest		Mean Gain
		Mean	Standard Deviation	Mean	Standard deviation	
Problem-based Learning	71	47.79	5.042	110.75	8.817	62.96
Problem-based and Text-book-with-assessment	88	46.65	3.350	116.99	4.632	70.34
Text-book-with-assessment	69	50.55	4.764	114.32	6.801	63.77
Conventional method	53	39.70	4.213	81.47	7,347	41.77

Table 4.2 shows that problem-based and textbook-with-assessment group had the highest post-test mean score in manipulative skills (Practical skills) (X=116.99), followed by TwA method (X=114.32), problem-based (110.75) and conventional method (X=81.47) in that order. When the post-test mean scores were compared with corresponding pre-test mean scores, the problem-based and textbook-with-assessment group also had the highest mean gain manipulative skills score of 70.34, TwA group had a mean gain of 63.77, PB had a mean gain of 62.96 and conventional method group had the least mean gain score of 41.77. All the groups however, had higher post-test manipulative skills mean scores than pre-test scores.

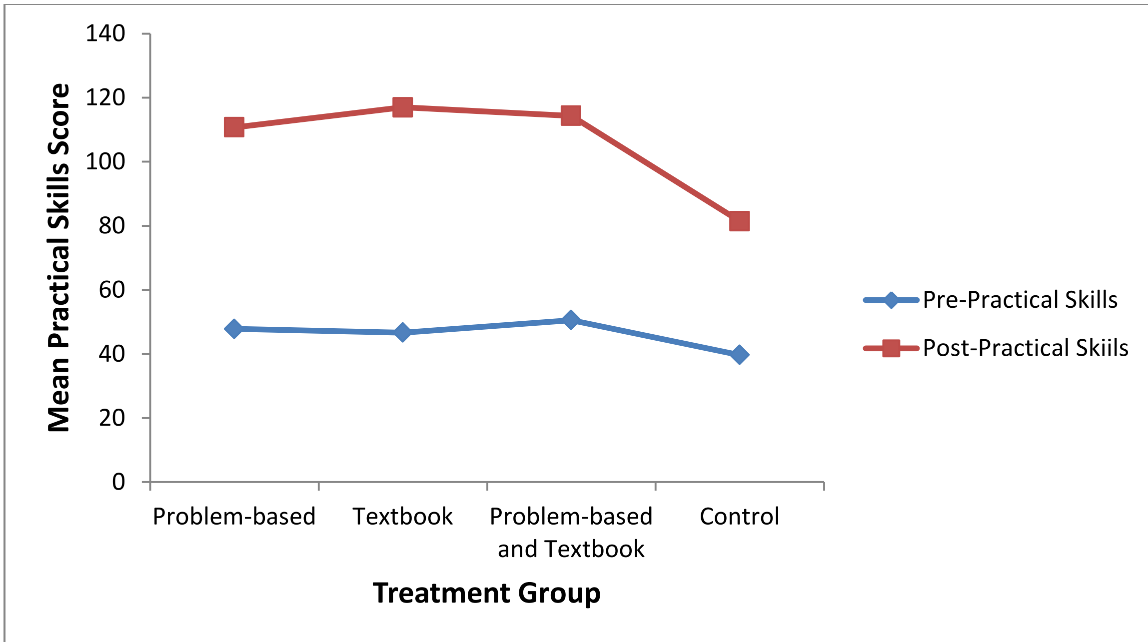

Fig 4.2: Pre-test and Post-test Manipulative Skills (Practical Skills) Mean Scores by Treatment.

The above results were an indication that the manipulative skills of the students in practical Chemistry were greatly improved by the treatments. The combination of PB and TwA approach showing the highest manipulative skill mean score was because the approach gave the students the privilege to do the practical Chemistry individually even in their small groups, received the assistance of their colleagues when needed and using the prescribed practical textbook.

Table 4.3: Summary of mean difference of students' academic achievement in Chemistry by opportunity to learn (OTL)

Opportunity to Learn	N	Pretest		Posttest		Mean Gain
		Mean	Standard Deviation	Mean	Standard deviation	
High	98	21.40	4.871	26.86	5.165	5.46
Moderate	87	21.47	5.009	27.29	5.041	5.82
Low	96	21.09	4.387	27.48	6.325	6.39

As captured in Table 4.3, the Chemistry students who had low OTL had the highest mean gain score in achievement in Chemistry (X= 6.39), followed by moderate

OTL students with mean gain score of 5.82. The high OTL students had the least mean gain scores in Chemistry achievement (X=5.46). All the OTL groups had higher mean post-test scores (High=26.86, Moderate= 27.29 and Low= 27.48) than mean pre-test scores of 21.40, 21.47 and 21.09 for high, moderate and low, respectively.

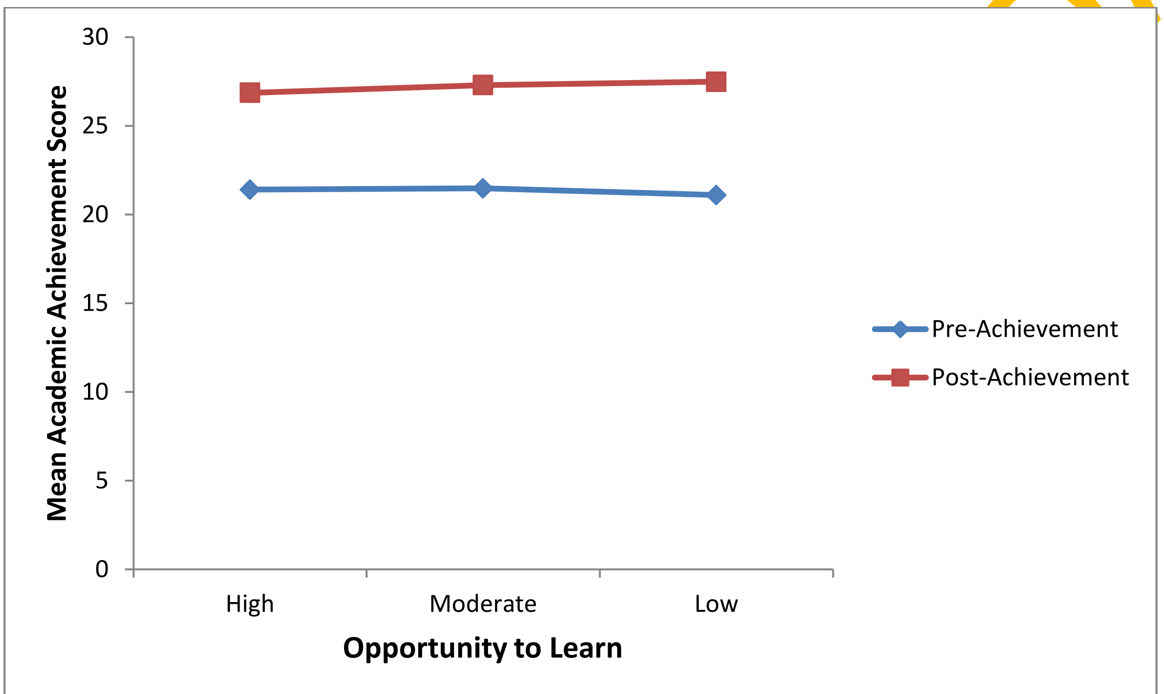

Fig 4.3: Pre-test and Post-test Academic Achievement Mean Scores by OTL

The above result was so because the students took for granted the privilege of high OTL and did not make judicious use of it and that affected their performance. On the other hand, students with low OTL utilized wisely whatever improvisation made available to them and put in effort to improve their performance. This resulted in higher post-test mean score than the group with high OTL.

Table 4.4: Summary of mean difference of students' manipulative skills in Chemistry practical by opportunity to learn

Opportunity to Learn	N	Pretest		Posttest		Mean Gain
		Mean	Standard Deviation	Mean	Standard deviation	
High	98	46.74	63.48	107.64	16.851	60.90
Moderate	87	46.56	5.929	107.18	15.202	60.62
Low	96	46.44	4.574	109.27	13.174	62.83

Table 4.4 contains the pre-test and post-test mean scores of students' manipulative skills in Chemistry practical based on high, moderate and low OTL students. The pre-test mean score for high OTL students was 46.74, as against post-test score of 107.64. For those that had moderate OTL, pre-test and post-test mean scores were 46.56 and 107.18, respectively. The low OTL students had a mean pre-test score of 46.44 and mean post-test score of 109.27. The three groups had post-test mean manipulative skills scores higher than their corresponding pre-test mean manipulative skills scores. Also, the low OTL students have highest mean gain manipulative skills scores (X=62.83) followed by high OTL students (X=60.90) while moderate OTL students had the least mean gain manipulative skills score (X=60.62).

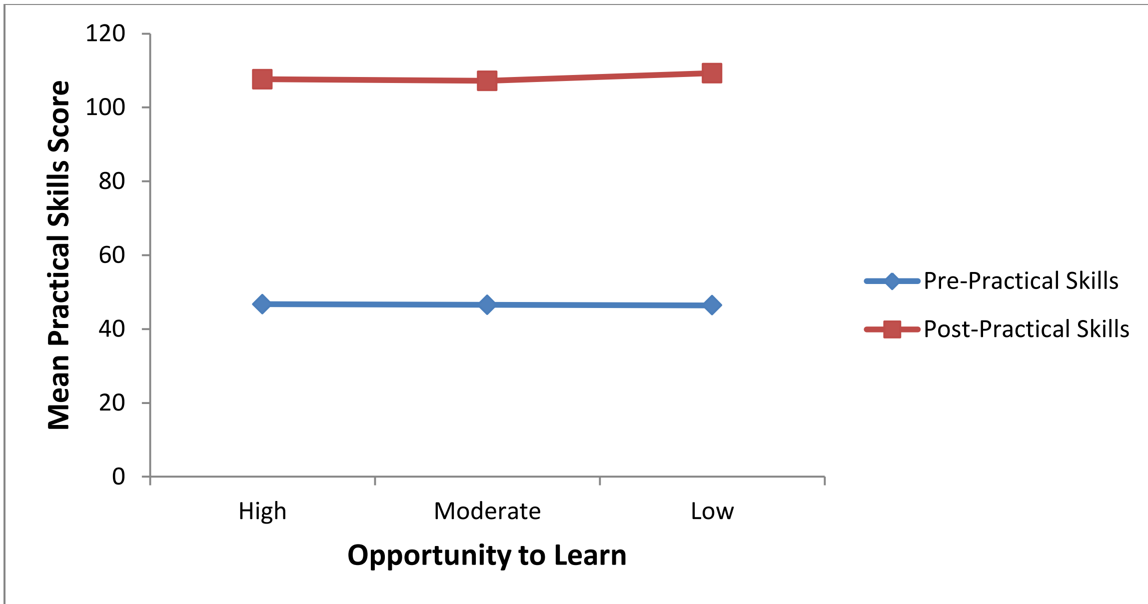

Fig. 4.4: Pre-test and Post-test Manipulative Skills (Practical Skills) Mean scores by OTL

The results on both Table 4.4 and Fig. 4.4 showing higher post-test manipulative skills mean scores than pretest mean scores irrespective of high moderate and low OTL. As a matter of fact, the students' improved performance was as a result of the new approaches used by the teacher and not necessarily the availability or not of the apparatus and reagents provided for the students' practical in Chemistry.

Table 4.5: Summary of mean difference of students' academic achievement in Chemistry by school type

School Type	N	Pretest		Posttest		Mean Gain
		Mean	Standard Deviation	Mean	Standard deviation	
Single-sex	159	20.41	4.299	28.10	5.654	7.69
Coeducational	122	22.50	5.039	26.03	5.181	3.53

From Table 4.5, students from single-sex federal government colleges had mean gain achievement score (X=7.69) in Chemistry higher than those in coeducational colleges with a mean gain score of 3.53. This could be because there was no gender sensitivity in the single-sex colleges. No gender influence on any one's performance, consciously or unconsciously, as would have been the case in coeducational colleges.

Students from the two types of schools had higher post-test mean scores in achievement in Chemistry with values 28.10 and 26.03 respectively, than pre-test mean scores 20.41 and 22.50 respectively too. Fig. 4.5, reveals a higher posttest than pre-test scores in Chemistry between single-sex and coeducational colleges. This simply showed that the learning approaches improved the students' performance in Chemistry.

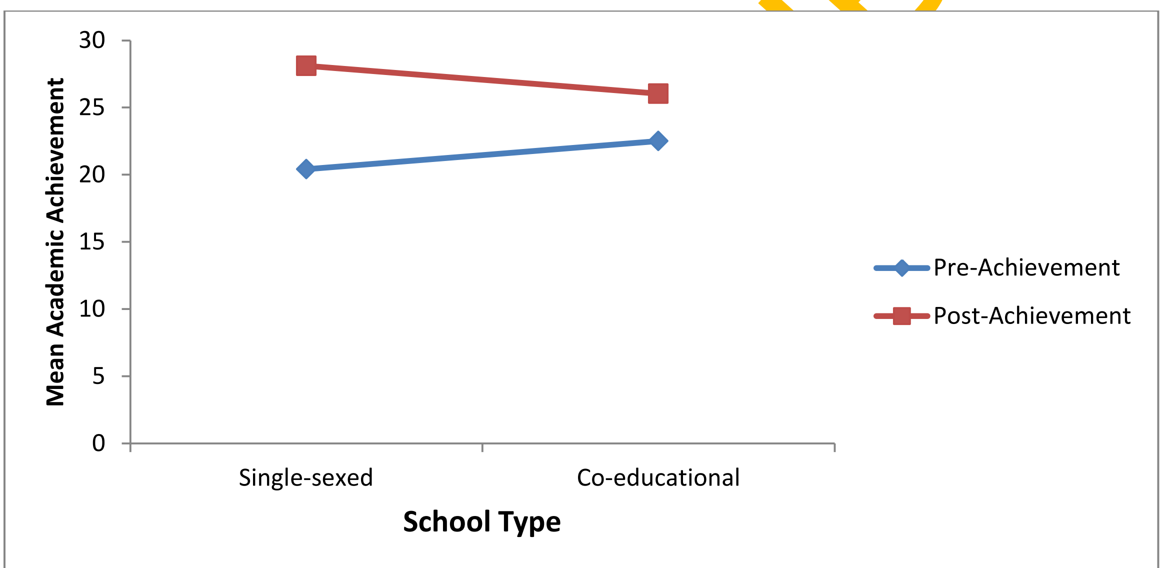

Fig.4.5: Pre-test and Post-test Academic Achievement Mean Scores by School Type

Table 4.6: Summary of mean difference of students' manipulative skills (Practical Skills) in Chemistry by school type

School Type	N	Pretest		Posttest		Mean Gain
		Mean	Standard Deviation	Mean	Standard deviation	
Single-sex	159	48.69	5.033	112.28	7.177	63.59
Coeducational	122	43.84	5.218	102.55	19.557	58.71

Table 4.6 reveals that the post-test students' manipulative skills (practical skills) mean scores in Chemistry were higher in single-sex colleges (X=112.28) than those from coeducational colleges with post-test manipulative skills mean score of 102.55. Also, students from single-sex colleges had a greater mean gain score (63.59) than their coeducational colleges' counterpart with mean gain score of 58.71.This is shown in Fig.4.6 below. These results were indications that students in single-sex colleges showed more interest and commitment in their Chemistry practical leading to better performance. On the other hand, possibility of gender sensitivity in the coeducational colleges influenced their performance in manipulative skills in Chemistry practical.

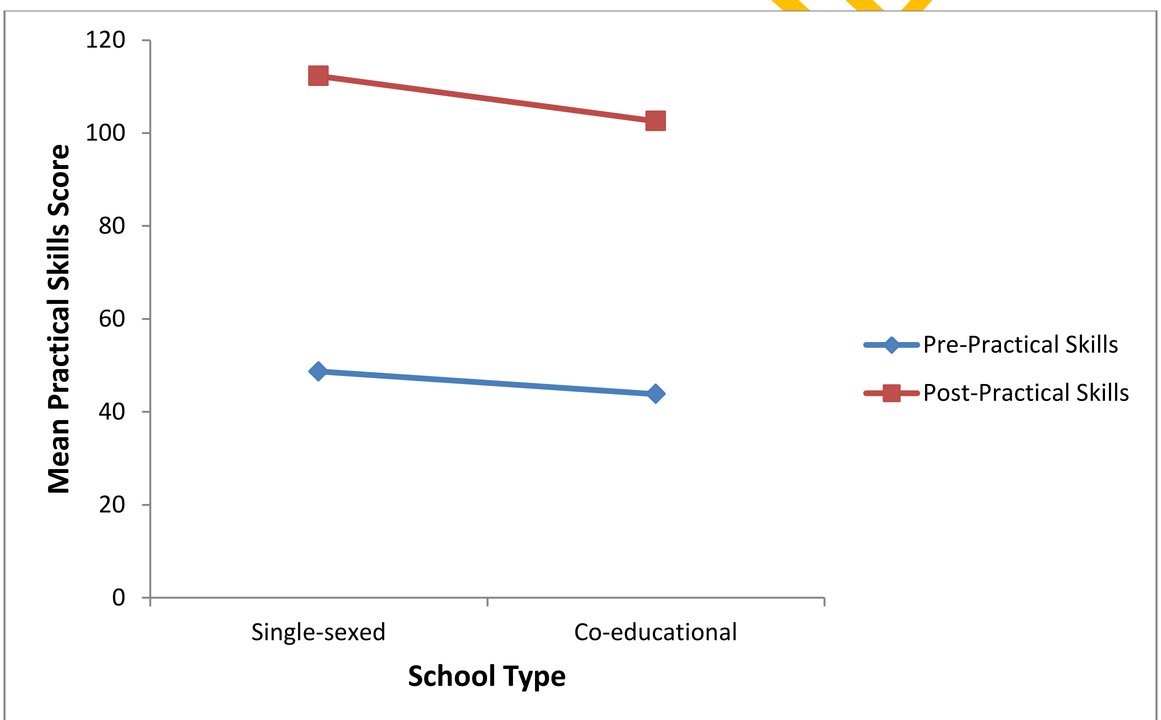

Fig.4.6: Pre-test and Post-test Manipulative Skills (Practical Skills) Mean Scores by School Type

4.2 Testing of hypotheses

Hypothesis 1:

4.2.1 Result and discussion

4.2.1.1 Ho 1 (i): There is no significant main effect of treatment (learning approaches) on students' academic achievement in Chemistry

Table 4.7: Analysis of covariance (ANCOVA) of post-test mean scores of students' academic achievement in Chemistry by treatment, opportunity to learn and school type

Source of Variation	Type 111 sum of squares	DF	Mean square	F	P-Value	Eta squared
Corrected model	3747.970	18	208.221	11.259	.000	.436
Intercept	1531.984	1	1531.984	82.836	.000	.240
Pre Achievement	2600.560	1	2600.560	140.615	.000	.349
Treatment	880.990	3	293.663	15.879	.000*	.154
OTL	4.727	2	2.363	.128	.880 NS	.001
School Type	9.835	1	9.835	.532	.467 NS	.002
Treatment OTL	140.524	6	23.421	1.266	.273 NS	.028
Treatment School Type	127.806	1	127.806	6.911	.009 *	.026
OTL School Type	11.161	2	5.581	.302	.740 NS	.002
Treatment, OTL , School Type	13.883	2	6.942	.375	.687 NS	.003
Errors	4845.468	262	18.494			
Total	216532.000	281				
Corrected Total	8593.438	280				

R square= .436 (Adjusted R square=.397)

* = Significant at P< 0.05

NS= Not significant at P< 0.05

The results in Table 4.7 indicate that there was significant main effect of learning approaches (PB, TwA, PB and TA and Conventional approaches) on students' academic achievement in Chemistry [F (3,262)=15.879,P< 0.05). Further examination revealed that the improved academic achievement was greater on Chemistry students exposed to Problem-Based, Textbook-with-Assessment and the combination of Problem-Based and Textbook-with-Assessment than those exposed to conventional method. Since the P-value of the F-ratio was significant, it follows that hypotheses one on the main effect of learning approaches on students' academic achievement in Chemistry was rejected. This simply means that the learning approaches improved the performance of the students in Chemistry. The adjusted R square value of .397 indicates that the independent variables accounted for 39.7% of the variation in the students' academic achievement in Chemistry. The partial Eta squared estimated was .154. This implies that treatment accounted 15.4% of the variance observed in posttest academic achievement in Chemistry.

Table 4.8: Scheffe post hoc multiple comparison of academic achievement in Chemistry by treatment

(I)Treatment	(J)Treatment	Mean difference (I-J)	Std Error	P-Value
PB	TwA,	3.74	.899	.001*
	PB & TwA,	1.41	.849	.429
	Conventional	4.32	.966	.000*
TwA	PB	-3.74	.899	.001*
	PB & TwA	-2.33	.856	.062
	Conventional	.58	.972	.949
PB & TwA	PB	-1.41	.849	.479
	TwA	2.33	.856	.062
	Conventional	2.91	.925	.021*
Conventional	PB	-4.32	.966	.000*
	TwA	-.58	.972	.949
	PB & TwA	-2.91	.925	.021*

*= Significant at P< 0.05

Table 4.9: Scheffe post hoc means for groups in homogeneous subset by treatment

Treatment	N	Subset		
		1	2	3
Conventional	53	25.06		
TwAL	69	25.64	25.64	
PB & TwAL	88		27.97	27.97
PBL	71			29.38

Results in Tables 4.8 and 4.9 reveal that there was a significant difference between mean scores of problem-based group (X=29.38) and conventional group (X=25.06). Also, mean difference between problem-based group and textbook-with-assessment group (X=25.64) was significant. Combination of problem-based and textbook-with-assessment group (X=27.97) also differed significantly in mean difference from that of the conventional group. These significant mean differences observed were all in favour of the problem-based approach, which portrays high characteristic potential imbedded in the approach. The tables also show that there was no significant difference in the mean scores of problem-based and the combination of problem-based approach and TwA; textbook-with-assessment and conventional and between textbook-with-assessment and combination of problem-based and textbook-with-assessment.

The problem-based approach showed the greatest positive impact on the students' learning. This could be because problem scenario examples: purification of impure water and removal of hardness in water, which the students identified with, were used as starting point for the new knowledge they acquired in water treatment lessons. This is in agreement with the work of Chukwuka (2006), in which students used problem-solving techniques to control environmental menace in a community applying the knowledge of Biology. The result of this study also corroborates the assertions of Visconcelos (2010), whose study was based on the principle of using problem as a starting point for the acquisition of new knowledge. The claims from the studies of Orji (1998), Stevens (2005) and Majumder (2008), that PB learning is bringing real-life situation into the learning of Chemistry, thereby improving the performance of the students, was further confirmed by the result of this study. The combination of PB and TwA approaches which as well recorded notable improvement in the performance of the students in Chemistry, agrees with the result of the work of Romack (2006), which he terms "Readiness Concept". When he introduced it to his students, he recorded remarkable improvement in the students' performance.

4.2.1.2 Ho 1 (ii): There is no significant main effect of treatment (learning approaches) on students' Manipulative skills (Practical skills) in Chemistry.

Table 4.10: Analysis of Covariance (ANCOVA) of Posttest Means Score of Students' Manipulative Skills (Practical Skills) in Chemistry by Treatment, Opportunity-to-learn and School Type

Source of Variation	Type 111 sum of squares	DF	Mean square	F	P-Value	Eta squared
Corrected model	50321.957	18	2795.664	68.859	.000	.826
Intercept	17578.186	1	17578.186	432.963	.000	.623
Pre Practical skills	664.571	1	664.571	16.369	.000	.059
Treatment	25771.657	3	8590.552	211.591	.000*	.708
OTL	60.728	2	30.364	.748	.474 [NS]	.006
School Type	1554.625	1	1554.625	38.292	.000*	.128
Treatment OTL	228.932	6	38.155	.940	.467[NS]	.021
Treatment School Type	342.004	1	342.004	8.424	.004*	.031
OTL School Type	28.185	2	14.093	.347	.707 [NS]	.003
Treatment, OTL, School Type	33.877	2	16.938	.417	.659 [NS]	.003
Errors	10637.132	262	40.600			
Total	3342000.000	281				
Corrected Total	**60959.089**	**280**				

R square= .826 (Adjusted R square=.814)

* = Significant at P< 0.05

NS= Not Significant at P< 0.05

Table 4.10 presents the results of analysis of covariance (ANCOVA) for main effect of treatment (PB, TwA, PB & TwA and conventional (approaches) on students' manipulative skills in Chemistry practical. The result showed that, after adjusting covariate, there was significant main effect of learning approaches on students' manipulative skills in Chemistry practical [F (3,262)=211.591, P<0.05). The P value (.000) was less than 0.05 level of significance. So Ho_1 (ii) was rejected. From the adjusted R squared value of .814, the independent variables accounted for 81.4% of the variation observed in students' manipulative skills in Chemistry practical. The partial Eta squared estimated for treatment was .708. This also shows that treatment (learning approaches) accounted for 70.8% of the variance observed in students' manipulative skills in Chemistry practical.

Table 4.11: Scheffe post hoc multiple comparison of manipulative skills in Chemistry practical by treatment

(I) Treatment	(J) Treatment	Mean Difference(I-J)	Standard Error	P-Value
PB	TwA	-3.57*	1.108	.017
	PB & TwA	-6.24*	1.046	.000
	Conventional	29.27*	1.190	.000
TwA	PB	3.57*	1.108	.017
	PB & TwA	-2.67	1.054	.096
	Conventional	32.85*	1.197	.000
PB & TwA	PB	6.24*	1.046	.000
	TwA	2.67	1.054	.096
	Conventional	35.52*	1.140	.000
CONVENTIONAL	PB	-29.27*	1.190	.000
	TwA	32.85*	1.197	.000
	PB & TwA	-35.52*	1.140	.000

*= The mean difference is significant at P< 0.05

Table 4.12: Scheffe post hoc mean for groups in homogeneous subset by treatment

Treatment	**N**	**Subset**		
		1	**2**	**3**
Conventional	53	81.47		
PB	71		110.75	
TwA	69			114.32
PB & TwA	88			118.99

*= The mean difference was significant at P< 0.05

Multiple comparison post hoc tests, presented in Tables 4.11 and 4.12, shows treatment levels on students' manipulative skills in Chemistry practical. It reveals which category is significantly different. So, from the displayed results, it is deduced that the mean manipulative skills scores of students in conventional approach significantly differed from all other treatment groups, which are student-centred, indicating that those approaches impacted more positively on students' manipulative skills than the conventional approach, which is teacher-centred. The mean manipulative skills scores of students in TwA group (114.32) was significantly different from those of PB (110.75) but did not differ significantly from those in PB & TwA (118.99), which shows the highest positive impact on the students' manipulative skills learning.

The above results imply that the treatment improved the students' manipulative skills (practical skills) in Chemistry with PB approach showing a pronounced contribution to this improvement on the students' manipulative skills. The reason could be because, during the intervention, while in their groups, the students were allowed to use the Chemistry practical apparatus individually up to the point of mastery. This boosted their confidence and interest, the result of which showed in their improved performance in practical Chemistry post-test scores. The result agrees with the work of Grant and Spencer, (2003), which emphasizes the importance of Personalized System of Instruction/learning (PSI) and students' centredness. Because the students had been allowed to use the apparatus to carry out the practical instructions long enough and had been given ample opportunity to practice with these apparatus, they developed some characteristic expertise in operating them, making it easier for them to use them during Chemistry practical tests/examinations. The results also conform with the problem expressed in the chief examiners' reports of NECO and WAEC (2004-2006), which state that students do not have firm grip of the use of Chemistry practical apparatus and cannot relate them to their functions. It is clear from the study that the students could show expertise in their manipulation of some Chemistry apparatus because they have the opportunity of being exposed to them before practical test/examination. The skill they now acquired would then enable them to use any of those apparatus or a related one anywhere any time.

The result as well reflects the findings of Hmelo-Silver (2002) and (2004), which emphasize the monitoring duty of the facilitator (Chemistry teacher) to ensure that all students are involved and encouraged to externalize their own thinking and to comment on one another's thinking concerning their discoveries. The teachers' effective monitoring during the treatment sessions resulted in this improved performance in practical Chemistry.

In the case of textbook-with-assessment (TwA), the result showed improvement on the students' manipulative skills in Chemistry practical. This agrees with the work of Osokoya (1998), which emphasizes the importance of textbook studies in the learning of practical Chemistry for improved performance among science students. Concerning assessment skills, since the same textbooks used by the students during lessons were the same sources from where the examination questions were raised, this made it easier for the students during the posttest examinations. Having treated closely related questions during class lessons, they recorded better achievement. The positive impact of these two approaches on the manipulative skills of the students, explains the high mean scores recorded by the combination of PB and TwA approaches on the students manipulative skills in Chemistry practical.

4.2.2.1 Hypothesis 2; Ho 2 (i): There is no significant main effect of opportunity to learn on students' academic achievement in Chemistry.

Table 4.3 reveals that students that had low OTL had highest mean gain score (X=6.39) in Chemistry academic achievement, followed by moderate OTL students, with mean gain score of 5.82. Students that claimed to have highest OTL had the least mean gain score (X=5.46). With reference to Table 4.7, it could be deduced from the adjustment of the covariate that F (2,262), indicating the main effect of OTL on students' academic achievement in Chemistry was 0.128; P>0.05, since P value (0.880) is greater than 0.05 alpha level, then there was no significant main effect of OTL on students' academic achievement in Chemistry. So, Ho2 (i) was not rejected. The partial Eta square of 0.001 implies that OTL accounted for 0.1 % of the variance observed in the posttest academic achievement in Chemistry.

The above result shows that students with low OTL had better scores than those with high OTL. This means that there may be other factors that cause low achievement in Chemistry other than unavailability of facilities and poor curricula implementation. This is contrary to the findings of Onu (2007), which emphasize that students have opportunity to learn through a wide range of carefully designed science activities and materials from which they freely choose in order to understand science concept better and improve their achievement. Also, it does not agree with the studies of Raimi (2002) Adeyegbe (2005) and Julius (2007), which note that inadequate laboratory facilities and exposure to their use is a major contributory factor to the poor achievement of students in Chemistry. Further, the result does not support the views of Schwartz (1995), which states that common sense dictates that, in order for students to achieve, they must have appropriate opportunities to learn. This implies that as important and necessary as the variable OTL is to learning practices, it is still not indispensible to students' achievement in Chemistry learning.

4.2.2.2 Ho 2 (ii): There is no significant main effect of OTL on students' manipulative skills in Chemistry practical (practical skills in Chemistry).

It is revealed from Table 4.4 that students with low OTL had highest mean gain score of (X=62.83) in Chemistry manipulative skills, followed by those with high OTL (60.90); but students with moderate OTL had the least mean gain score (60.62) in Chemistry manipulative skills. Considering the adjustment of covariate (Table 4.10), the posttest scores $F_{(2,262)}$, indicating the main effect of OTL on students' manipulative skills in Chemistry practical, was 0.748; P>0.05. Therefore, Ho2 (ii) was not rejected because there was no significant main effect of OTL on students' manipulative skills in Chemistry practical. The partial Eta square value of 0.006 showed that OTL accounted for 0.6 % of the variance noticed in the posttest students' manipulative skills in Chemistry, indicating that factors other than OTL were the major contributors to the difference observed.

The students with low OTL performed better than those with high and moderate OTL, both in manipulative skills in Chemistry practical and academic achievement in Chemistry. The result indicates that students' OTL was not the source of motivation to improve their manipulative skills in Chemistry. This is because, the students whose laboratory was equipped, the Chemistry teacher ready and willing to engage them in regular practical lessons, took the privilege for granted and never utilized the opportunity to improve their performance. Conversely, the students that had inadequate or insufficient practical facilities, human and material, probably utilized every improvised item and available helps provided to them to enhance their manipulative skills in Chemistry practical.

Hypothesis 3

4.2.3.1 Ho 3 (i): There is no significant main effect of school type on students' academic achievement in Chemistry.

Table 4.5 shows pretest and posttest mean gain scores of students' academic achievement in Chemistry from single-sex and coeducational colleges. The table reveals that students from single-sex colleges had higher mean gain scores (X=7.69) than those from coeducational colleges (X=3.53). Table 4.7 shows that there was no significant main effect of school type (single-sex and coeducational) on students' academic achievement in Chemistry; [F (1,262)=0.532],P> 0.05)]. Since P value of .467 was higher than 0.05 level of significance, the hypothesis on main effect of school type on students' academic achievement was not rejected, but accepted. Therefore, school type has no effect on academic achievement of students in Chemistry. The partial Eta squared estimated .002 reveals that school type accounted for 0.2% of the variance observed in the posttest of students' academic achievement in Chemistry.

This result simply indicates that the type of school does not necessarily matter when a teacher wants to use any of the approaches in this study in a Chemistry class. This is in accordance with the result of the study of Riordan (1994), who notes that educational outcomes for white males seem relatively unaffected by whether they are schooled in a coeducational or a single-sex school. So the type of school a student attends does not necessarily influence higher academic achievement whether single-sex or coeducational from the result of this study.

4.2.3.2 Ho 3 (ii): There is no significant main effect of school type on students' manipulative skills in Chemistry practical (practical skills in Chemistry).

Table 4.6 shows that students from single-sex colleges had higher mean gain score (X=63.59) in manipulative skills in Chemistry compared to their coeducational counterparts, with mean gain manipulative skills score of 58.71.This result implies that students from single-sex colleges were better in manipulative skills in Chemistry practical than the coeducational college students after the use of the treatment. Table 4.10 shows that there was significant main effect of school type on students' manipulative skills in Chemistry [$F_{(1,262)}=38.292, P<0.05$)]. In view of this result, hypothesis Ho3 (ii) was rejected because school type had significant main effect on students' manipulative skills in Chemistry. The partial Eta square value of 0.128 indicated that school type accounted for 12.8% of the variance observed in the posttest students' manipulative skills in Chemistry, which was significant enough to make a difference.

Further analysis of the result revealed that students from single-sex colleges had higher mean gain scores in manipulative skills in Chemistry practical than their counterparts in coeducational colleges, meaning that they performed better in manipulative skills than the students from coeducational colleges after the treatment. The reason could be that of gender sensitivity, in which female students in coeducational colleges are less active in their heterogeneous group leaving the male students to do most of the practical works, thereby slowing down the activity rate which may lead to incomplete exercise consequent to slow perception and low scores. Conversely, in a single-sex school there is no such gender sensitivity; everyone is there on his or her own right for the Chemistry practical and participates fully at every stage of the exercise. This full and unreserved participation leads to better performance in manipulative skills in

Chemistry in a single-sex school, shown in the result above. So, Chemistry teachers in single-sex colleges can freely use any of the approaches in this study to teach practical Chemistry.

4.2.4 Two-way Interaction Effects: Hypothesis 4

4.2.4.1 Ho 4 (i): There is no significant interaction effect of treatment (Learning approaches) and OTL on students' academic achievement in Chemistry.

Table 4.7 reveals that there was no significant two-way interaction effect of treatment with OTL on students' academic achievement in Chemistry [$F(6,262)=1.266$; $P> 0.05$)].This implies that Ho4 (i) was not rejected, but accepted, because students' OTL had no effect on the treatments (PB, TwA, PB & TwA and conventional learning approaches) used in this study.

This result agrees with the hypothesis of no interaction effect of treatment and OTL on students' academic achievement in Chemistry. This means that Chemistry teachers can use any of the approaches whether the students have OTL or not. But it is contrary to the result of the study of Osokoya (1998), which claims that textbook reading contributes immensely to students' achievement in Chemistry and that students are likely going to perform better if examination questions are raised to cover only the portions of the syllabus already treated. Also, the works of Okonkwo (2004) and Denis (2006) observe that the textbook presents and represents the intentions of curriculum developers because the knowledge content for each subject and the class are revealed in them. So, as the students read the textbooks and attempt the assessment questions, their understanding of the topic is aided. Araz and Sungur (2007) stress the unquantifiable contribution of facilities like textbooks to the achievement of Chemistry students but this has been contradicted by the result of this study. All the same, teachers experience and qualification, which were rated very high in the study of Angus (2009) as a contributory factor to the excellent performance of students in Chemistry can play down on whatever negative effect facility and curriculum inadequacy would have on the students' excellent performance in Chemistry whether there is OTL or not. This presupposes that the learning approaches could be effectively used by practicing Chemistry teachers, whether the Chemistry students have opportunity to learn or not.

4.2.4.2 Hypothesis Ho 4 (ii) : There is no significant interaction effect of treatment and OTL on students' manipulative skills in Chemistry practical (practical skills in Chemistry).

Table 4.10 indicates that the F (6,262) presenting the two-way interaction effect of treatment and OTL on students' manipulative skills in Chemistry was 0.940; P> 0.05. Therefore, since P (0.467) was greater than 0.05, it could be deduced that there was no significant interaction effect of treatment and OTL on students' manipulative skills in Chemistry, resulting in Ho4 (ii) being accepted and not rejected. It then means that OTL, whether high, moderate or low, has no effect on the use of treatment (learning approaches) to improve students' manipulative skills in Chemistry. In other words, whether OTL is low, moderate or high, the achievement of students in practical Chemistry is not likely to change if any of the learning approaches is used in teaching.

4.2.5.1 Hypothesis 5

Ho 5 (i): There is no significant interaction effect of treatment (Learning approaches) and School Type on students' academic achievement in Chemistry.

Table 4.7 reveals that there was significant interaction effect of treatment and school type on students' academic achievement in Chemistry [F (1,262)= 6.911; P<0.05)]. Because of this result, Ho5 (i) was rejected because school type, whether single-sex or coeducational, significantly affected the students' academic achievement in Chemistry when learning approaches employed in this study were used during classroom teaching/learning. In other words, the academic achievement of students in Chemistry from either single-sex or coeducational colleges was affected whenever any of the learning approaches in this study was used in the teaching of Chemistry.

To find the nature and the pattern of the interaction, a graph was plotted, as shown on Figure 4.7.

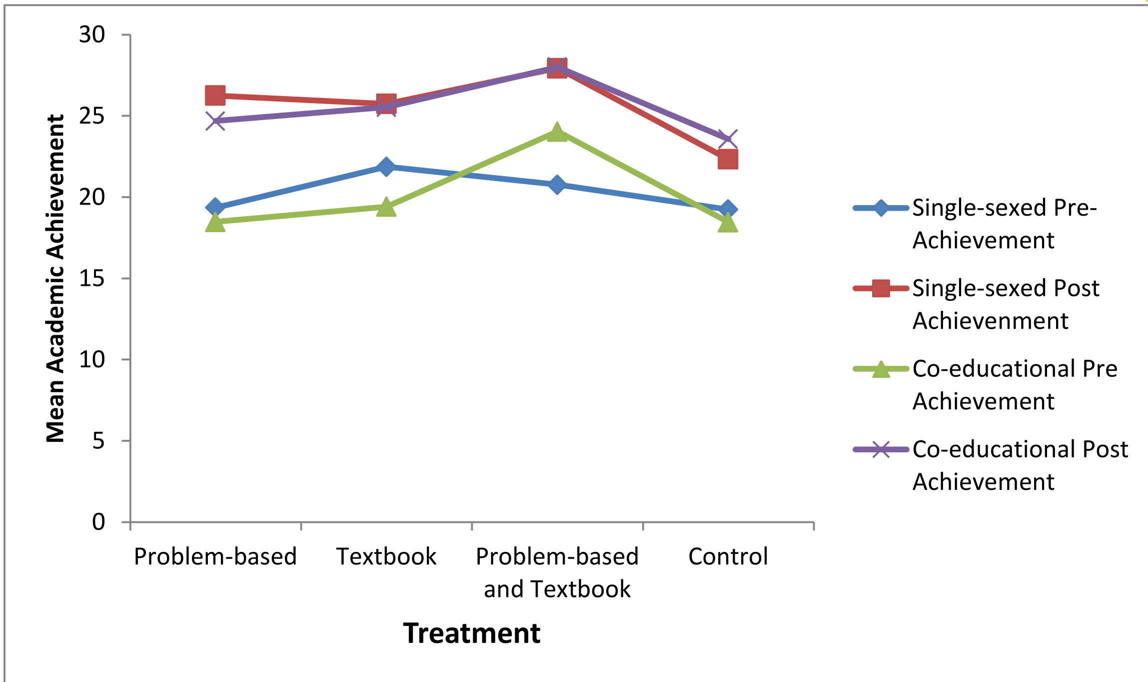

Fig. 4.7 Graph of Interaction Effect of Treatment and School Type on Students' Academic Achievement in Chemistry

It could be deduced from Figure 4.7 that the interaction effect of treatment on students in coeducational colleges outweighed those of the single-sex colleges in both pre-test and post-test academic achievement in Chemistry. This shows that students from single-sex colleges gained more through the treatment than their coeducational counterparts.. Hence, hypothesis five H_0 5(i) was rejected.

The above result is supported by the assertion of Rojas (2000) that a single-sex school for boys or girls has seen first-hand the impact of eliminating social distractions that could come as a result of coeducational instruction. He notes that "We have seen many students start to focus heavily on academics. They no longer clown or try to impress the opposite sex… girls learning to be more academically competitive and boys are learning to collaborate." This corroborates the study of the Australian Council for Educational Research-ACER (2000) and the National Foundation for Educational Research-NFER (2002). They discovered that even after controlling students' academic ability and other background factors, both girls and boys did significantly better in single-sex schools than in coeducational schools. These studies state clearly that boys at the lower ability scale benefitted immensely by the single-sex school setting than coeducational setting thereby helping to solve the academic need of that category of boys.

The report of ACER (2000) also claims that "boys and girls in single-sex schools are more likely to be better behaved and to find learning more enjoyable and the curriculum more relevant'. It emphasizes that coeducational settings are limited by their capacity to accommodate the large differences in cognitive, social and developmental growth rates of boys and girls aged between 12 and 16 which would likely affect the students' performance. So, in order not to jeopardize the academic achievement of the students, single-sex arrangement could become a safer alternative.

On the contrary, the result of this study does not agree with the result of the study of Yates (2001) on the effect of coeducational school on students' achievement. He discovered that there were increases in educational achievement, and positive benefits were observed in students as a result of introduction of coeducation in their previously established single-sex schools.

These contradictory reports from different research findings, indicate that research, like time, is not static or its results stereotyped but changes with location and style. There are some factors which could be adequately built into or controlled during certain research programmes, but there are some which could not. So, the outcome or result of the research would definitely be influenced by the circumstances surrounding it. The result of this research demands that Chemistry teachers should consider the school set-up when choosing the teaching/learning approach to employ for optimum achievement by the Chemistry students

4.2.5.2 Ho 5 (ii): There is no significant interaction effect of treatment and school type on students' manipulative skills in Chemistry practical (practical skills in Chemistry).

Table 4.10 shows that there was significant interaction effect of treatment (PB; TwA; PB & TwA and conventional) approaches and school type (single-sex and coeducational) on students' manipulative skills in Chemistry practical [$F (1,262) = 8.424$, $P < 0.05$)]. Ho5 (ii) was then rejected. This depicts that school type (single-sex or coeducational) of students had effect on the treatments (learning approaches) used in this study. Chemistry teachers could use the learning approaches by considering the type of school, whether single-sex or coeducational. Fig. 4.8 shows a graph of interaction pattern based on treatment and school type.

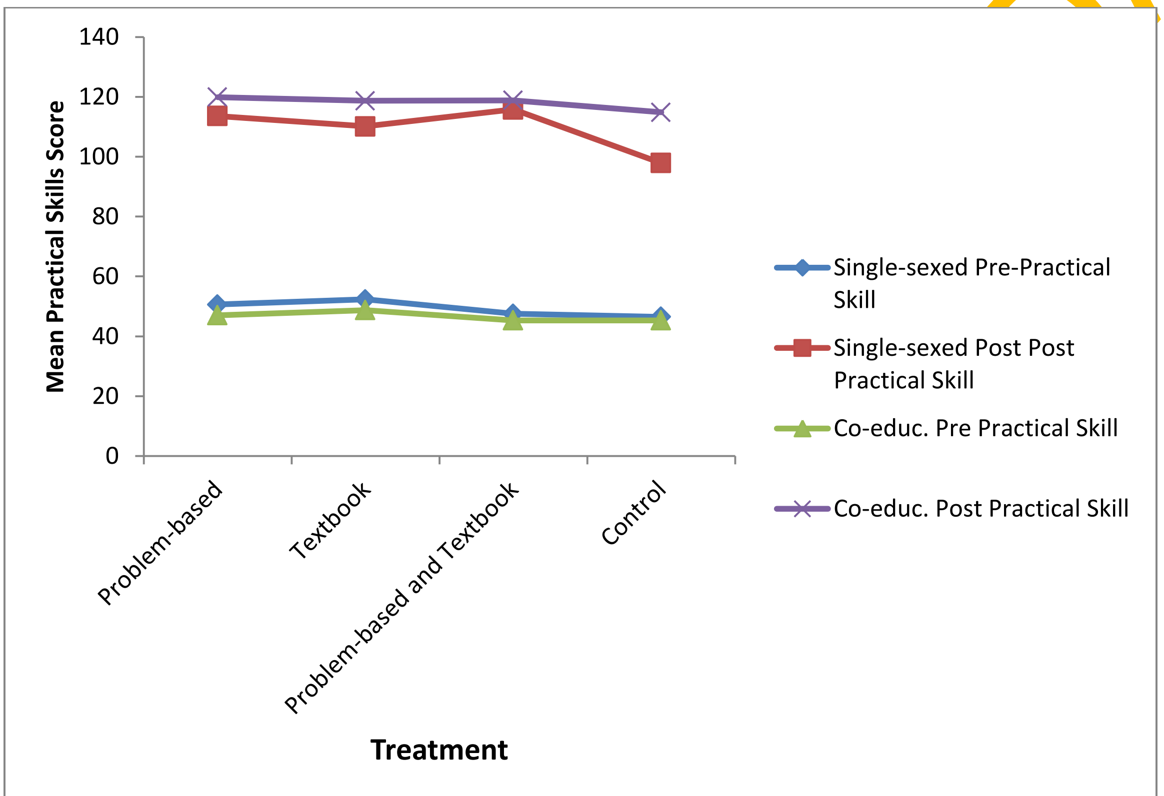

Fig. 4.8: Graph of Interaction Pattern between Treatment and School Type on Students' Manipulative Skills in Chemistry Practical (Practical Skills in Chemistry)

This Fig. 4.8 shows the pattern of interaction between treatment and school type on students' manipulative skills in Chemistry. It shows that treatment effect of interaction was greater on the students from coeducational colleges than on their single-sex counterparts. It is also observed from the graph that it was because they had lower achievement in both pre-test and post-test means manipulative skills scores than students from single-sex colleges who had greater positive responses to treatment in post-test mean manipulative skills scores.

The result simply means that Chemistry teachers could use any of the learning approaches in the teaching of practical Chemistry but should consider the type of school, whether single-sex or coeducational, for greater effectiveness. This is in agreement with the study of the British Office for Standards in Education (OFSTED, 1998), which found that students in single-sex schools had a significantly more positive attitude towards manipulative skills than their coeducation counterpart.

4.2.6 Hypothesis 6

4.2.6.1 Ho 6 (i): There is no significant interaction effect of OTL and School type on students' academic achievement in Chemistry.

The two-way interaction effect shown in Table 4.7 reveals the F (2,262) value of 0.302, which was not significant since P-value of 0.740 was greater than 0.05 level of significance. Therefore, Ho6 (i) was not rejected, because there was no significant interaction effect of OTL and school type on students' academic achievement in Chemistry. It implies that students' academic achievement in Chemistry was not affected by the interaction of OTL and school type. In other words, it is the same effect facility and curriculum inadequacy has on the academic achievement of students in single-sex colleges that it will have on coeducational colleges.

This does not agree with the view of ACER (2000) stated earlier, that boys and girls in single-sex schools are more likely to be better behaved and to find learning more enjoyable and the curriculum more relevant than students in coeducational setting. The authenticity of this report explains why most unruly behaviours and display of disobedience are likely going to be more pronounced in coeducational setting than in single-sex setting. Students in single-sex colleges would accommodate improvisation of apparatus and individual participation more readily than their counterparts in coeducational school, which was not captured by the result of this present study.

4.2.6.2 Ho 6 (ii): There is no significant interaction effect of OTL and school type on students' manipulative skills in Chemistry practical (practical skills in Chemistry).

Table 4.10 shows F (2,262) = 0.347, P> 0.05, that there was no significant interaction effect of OTL and school type on students' manipulative skills in Chemistry. This depicts that interaction of OTL and school type did not significantly affect students' manipulative skills in Chemistry. Therefore, the hypothesis was not rejected. This implies that there was no relationship between facilities and curriculum inadequacies and the type of school (single-sex or coeducational) a student attends with his/her achievement in practical Chemistry.

4.2.7 Three-way Interaction Effect: Hypothesis 7

4.2.7.1 Ho 7 (i): There is no significant interaction effect of treatment, OTL and school type on students' academic achievement in Chemistry.

Table 4.7 shows there was no significant interaction effect of treatment, OTL and school type on students' academic achievement in Chemistry [F (2,262)=0.375; P>0.05]. The effect of treatment on academic achievement in Chemistry was not sensitive to OTL and school type. So, Ho7 (i) was not rejected. It implies that there was no significant group difference on treatment among single-sex or coeducational colleges and low, moderate or high OTL Chemistry students. This suggests that practicing teachers could use PB and TwA approaches to support Chemistry teaching irrespective of OTL and school type.

The result of the three-way interaction above reveals that the learning approaches in this study can be used in the teaching/learning of Chemistry irrespective of low, moderate and high OTL and in either single-sex or in coeducational colleges, because the students' academic achievement would not be affected.

4.2.7.2 Ho 7 (ii): There is no significant interaction effect of treatment, OTL and school type on students' manipulative skills in Chemistry practical (practical skills in Chemistry).

The result presented in Table 4.10 indicates that the $F_{(2,262)}$ showing the three-way interaction effect of treatment, OTL and school type on students' manipulative skills in Chemistry was 0.417, P>0.05. Since P value (0.659) was greater than 0.05, there was no significant interaction effect of treatment, OTL and school type on students' manipulative skills in Chemistry. So, Ho7 (ii) was not rejected, but upheld.

From this result, it then follows that the earlier discovery of the effect of treatment observed on students' manipulative skills in Chemistry was not sensitive to students' OTL and the type of school attended. Consequently, when this was viewed against the background of the main effect of treatment and interaction effect of school type on students' manipulative skills, it suggests that teaching/learning could go on irrespective of whether students have OTL or not. But on the school type, the approach to be used should be given due consideration.

CHAPTER FIVE

SUMMARY OF FINDINGS, IMPLICATIONS, CONCLUSION, RECOMMENDATIONS AND SUGGESTIONS FOR FUTHER STUDIES

In this chapter, focus is on summary of findings of this study, the conclusion, recommendations and suggested areas for further studies.

5.1 Summary of Findings

The study of the effects of problem-based and textbook-with-assessment approaches on learning outcomes in secondary school Chemistry in federal government colleges, South-West, Nigeria, is pertinent in order to ascertain the teaching/learning strategy (ies) most adequate in Chemistry, in order to improve students' achievement which has dwindled for some years now. Some other strategies have been tried apart from the conventional method, but not much improvement has been recorded, hence the introduction of the above approaches. The findings of the study are summerised below:

1. There was significant main effect of the learning approaches (PB, TwA, PB & TwA and conventional) on students' academic achievement in Chemistry.
2. Chemistry students exposed to PB had highest academic achievement followed by the combination of PB and TwA, TwA and conventional learning approaches, in that order.
3. There was significant main effect of the learning approaches (PB, TwA, PB & TwA and conventional) on students' manipulative skills in Chemistry practical (practical skills in Chemistry).
4. Students exposed to PB & TwA had the highest manipulative skills in Chemistry practical followed by those exposed to TwA, PB and conventional approaches in that order.
5. There was no significant main effect of OTL on students' academic achievement in Chemistry and manipulative skills in Chemistry practical.
6. There was no significant main effect of school type on students' academic achievement in Chemistry.
7. There was significant main effect of school type on students' manipulative skills in Chemistry practical.

8. There was no significant interaction effect of the learning approaches and OTL on students' academic achievement in Chemistry and manipulative skills in Chemistry practical.
9. There was significant interaction effect of the learning approaches and school type on students' academic achievement in Chemistry and manipulative skills in Chemistry practical.
10. There was no significant interaction effect of OTL and school type on students' academic achievement in Chemistry and manipulative skills in Chemistry practical.
11. There was no significant interaction effect of the learning approaches, OTL and school type on students' academic achievement in Chemistry and manipulative skills in Chemistry practical.

5.2 Implications

The findings in this study show some interesting revelations and implications for the following groups of people: Chemistry students, teachers of Chemistry, school administrators and educational administration and planning section of the Federal Ministry of Education.

Chemistry students have been used to the conventional 'talk and chalk' and lecture methods of teaching and learning Chemistry. Therefore, rote learning has been the only way of learning they are used to. Concerted effort has to be made in order to convince the students to accept the new learning strategies and use them. For example, the PB approach requires that the students belong to small learning groups; they should be able to participate fully in order to contribute to knowledge thereby improve on their achievement. The textbook-with-assessment approach trains the students to use their textual materials adequately and effectively in the learning of Chemistry. They should be disciplined enough to study these textbooks on their own and attempt the adjoining questions to gain more knowledge to improve their achievement in Chemistry as well as their question-answering ability.

The teachers of Chemistry should be able to adopt the new approaches in their teaching or adapt them alongside the conventional methods. This will most likely make Chemistry teaching more interesting, student centred and result-oriented. The new approaches will eliminate or reduce to the barest minimum the usual monotonous 'chalk and note-dictating' style that have been the practice. As the coordinator or facilitator of learning, all the teacher needs do is to carefully identify problem scenarios that adequately relate to the topics in Chemistry syllabus he/she intends the students to learn, arranges the students in groups, organizes the relevant page and paragraph references and the corresponding assessment questions on the topics and presents them systematically to the students. In fact, this is more or less letting students do most of the work while the teacher coordinates all activities with ease and then sits back and enjoy the positive outcome of students' improved achievement in Chemistry.

The school administrators, for example the Vice-principal (Academics) and the Head of Science Department are not left out because they also have a lot to contribute to making these new approaches work in schools. These are the people that would supervise the teachers in the class during teaching. They should also ensure that the lesson plans of the Chemistry teachers and the test and examination items reflect the principles of the new approaches.

Parents also have their own part to play to ensure the success of the new approaches. They should endeavour to provide the textual materials their children and wards need. The availability of these materials will make the students committed to the implementing of the approaches for the anticipated improvement in achievement in Chemistry.

The Federal Ministry of Education should encourage more single-sex colleges for both males and females as this may yield better academic achievement.

5.3 Conclusion

The significant main effects of the learning approaches on students' academic achievement and manipulative skills in Chemistry practical is an indication that learning takes place faster and better when problem is used as a starting point for new knowledge. Students learn better when given opportunity to interact among themselves in small groups. When learning topics are structured to solve real-life problems, studying becomes fun and learning is facilitated and internalized.

Again, the study revealed that: when students study with their textbooks closely and regularly, their performance will be good. The lesson plan structured in such a way that students must study the recommended textbooks will improve learning and widen the students' knowledge horizon. Furthermore, assessment questions set with the recommended textbooks used during teaching/learning processes receive more positive responses from the students and the ripple effect could be minimizing or total eradication of examination malpractices among Chemistry students. Finally, as often as they use textbooks to study and record all the above-mentioned benefits, students' interests in reading textual materials will rise with increased optimism for better understanding of the topic of study and better academic achievement.

The positive impact of the learning approaches on the manipulative skills in Chemistry practical of the students is a proof that, when the problem is clearly defined and a textbook which has a step wise instruction of what to do is available to students, practical Chemistry lessons and examinations would be interesting and easy to do by the students. They will find it easier to relate apparatus with functions and theory with practice in Chemistry. Also, because they work in groups, the teacher as facilitator, students freely express their fears and ignorance to their fellow students and, by exchange of knowledge, they help one another understand faster. This yields better achievement for the students. Because there was no record of positive effect of OTL on the students' academic achievement in Chemistry and manipulative skills in Chemistry practical, there must be other factors responsible for students' poor achievement in Chemistry. So, the teachers can use any of the approaches in teaching with or without OTL for students.

The study also revealed that school type, specifically single-sex colleges, had effect on manipulative skills after being exposed to the learning approaches. This is an indication that single-sex arrangement has the ability to instil high level of self-confidence in students than coeducational colleges, making them participate fully in practical Chemistry, irrespective of the sex.

The overall result of this study indicates that the learning approaches experimented with improved the academic achievement of the students in Chemistry irrespective of low, moderate or high OTL and in any type of school. However, while teaching practical Chemistry, the teacher should bear in mind that students from same-sex colleges respond more positively to the learning approaches than their coeducational counterparts.

The post-test results of the group of students exposed to the conventional method of teaching/learning of Chemistry compared to those exposed to any of the other treatment groups were lowest both in academic achievement and in manipulative skills in Chemistry practical. This suggests that there is really an urgent need for a paradigm shift from conventional teaching/learning methods to a more student centred and result-oriented approaches.

5.4 Recommendations

Based on the findings of this study, it is recommended that:

1) Chemistry teachers in federal government colleges in particular should be sensitized to accept that there is an urgent need for a paradigm shift from the age-long conventional teaching/learning approaches to a more student-centred and result-oriented approaches. This shift could mean effective combination of the conventional and the PB, TwA and PB &TwA approaches in whatever proportion in the teaching of Chemistry.
2) This could be achieved if the Federal Ministry of Education can organize workshops and seminars where experts in this field will train the teachers on the implementation of these approaches in the teaching of Chemistry. Vice principals (academics) and heads of science department who are going to ensure and

monitor the implementation aspects should also take part in the training programmes.

3) School administrators should regularly inspect the teachers' lesson plans to ensure that they are prepared in accordance with the new approaches emphasizing full participation of students.

4) Teachers should encourage the students to be fully involved in the use of textbooks bearing in mind the Gail's (2009) view emphasizing the importance of textbook reading, '…if our students can't read the textbook, we as teachers are doing a disservice in not helping them read. After all, first, they learn to read, and thereafter, they read to learn. We have to help them read and understand textbooks; otherwise we haven't done our job''. The encouragement can also come in form of regular individual and group exercises (assignments) which should be adequately supervised and scored.

5) Students should be encouraged to open-mindedly co-operate with the efforts of the Chemistry teacher and the school authority, in general, in the use of these innovative learning approaches. For instance, every Chemistry problem and assignment based on textbook must be done and submitted with dispatch. They should also contribute fully during group exercises and discussions.

6) Parents should endeavour to buy the recommended textbooks and other textual materials for their children and wards to enable them participate fully in the class as lessons go on and during their personal reading time.

5.5 Suggestions for Further Studies

Future researchers can focus on the following areas:

1. This kind of research should be carried out in all the federal government colleges in other education zones in the country.
2. A comparative study can be done on this topic using state as well as privately owned colleges.
3. This study was based on Chemistry. This type of research can be done on other subjects as well.

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APPENDIX 1

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Chemistry Achievement Test (CHEMAT)

SCHOOL NAME:

SCHOOL TYPE: Boys ☐ Girls ☐ Mixed School ☐

AGE: 14-15 ☐ 16-17 ☐ 18-above ☐

CLASS:
TIME: 40mins
Instruction: Choose and circle the correct option A, B, C or D

OBJECTIVE QUESTIONS: ANSWER ALL QUESTIONS.

1. The two main types of water are -----------
A. Natural and untreated water. B. Pure and polluted water.
C. Treated and natural water D. Bottled water and pure water.

2. Which of these is not part of the group?
A. Rain water B. Lake water C. Spring water D. Hard water

3. The natural form of distilled water is ----------
A. Hard water B. Spring water C. Rain water D. Well water

4. Treated water is usually prepared for the following special purposes except --------
A. Distilled water for use in laboratories and industries B. Pipe-borne water for township use C. Chlorinated water for swimming pools D. Domestic water heaters

5. Pipe-borne water is usually produced in ----------
A. Reservoirs B. Water-treatment plant C. Electric generating plant
D. Drums and plastic tanks.

6. The chemical that kills germs in the water-treatment plant is--------
A. Alum B. Chlorine C. Iodin D. Fluorine

7. The chemical that prevents tooth decay in treated water is-------
A. Chlorine B. Fluorine C. Sodium chloride D. Calcium chloride

8. Hard water wastes soap because large amount of soap is needed to
A. Precipitate and remove the Calcium and Magnesium ions and then for actual washing.
B. Remove the Calcium and Magnesium ions and then for actual washing
C. Precipitate the Magnesium metal and then for actual washing
D. Precipitate and remove the Calcium and Magnesium ions

9. The chemical formula of gypsum is--------
A. $CaSO_4.3H_2O$ B. $CaPO_4.2H_2O$ C. $CaHSO_4.2H_2O$ D. $CaHSO_3.2H_2O$

10. Temporary hardness of water is caused by the presence of---------
A. Calcium hydrogentrioxocarbonate (IV) B. Calcium hydrogentetraoxocarbonate (IV)
C. Calcium tetraoxosulphate (VI) D. Calcium trioxocarbonate (IV)

11. Which of these statements is true of hard water?
A. Degree of hardness of water is directly proportional to the amount of soap needed.
B. Degree of hardness of water is indirectly proportional to the amount of soap needed.
C. Degree of hardness of water is neutral to the amount of soap needed.
D. Degree of hardness of water is directly proportional to the amount of soluble salts it contains

12. A pillar of Calcium trioxocarbonate (IV) structure growing downwards from the roof of a cave is known as--------
A. Stalagmite B. Stalactite C. Gypsum D. Zeolite

13. All but one is used in the removal of permanent hardness of water.
A. Washing soda B. Caustic soda C. Gypsum D. Zeolite

14. Which of the following is not an advantage of hard water?
A. It helps to build strong teeth and bones in animals B. It helps snails and crabs to make their shells C. It is used in dyeing and tanning D. It tastes better than soft water.

15. Which of these is not a common water pollutant?
A. Sewage B. Permanent hard water
C. Industrial wastes D. Agricultural wastes

16. Which of the following defines electrolyte?

A. A compound which conducts electricity and is not decomposed in the process.
B. A compound which does not conduct electricity but is decomposed by heat
C. A compound which conducts electricity and is decomposed in the process
D. A compound which conducts electricity only as a solid salt.

17. Electrodes are not used inform of ----------
A. Crystals B. Wires C. Rods D. Plates

18. Anode is----------
A. A positive electrode
B. A negative electrode
C. An entrance point of electrons into the electrolyte
D. An exit point of conventional current from the electrolyte

19. In an electrolytic cell reduction reaction occurs at the------------
A. Anode B. Cathode
C. Electrolyte D. Battery terminals

20. Electrolytes conduct electricity because they---------
A. ionize B. Do not ionize C. Are covalent D. Are mostly organic solutions

21. All but one are examples of the process of electrolysis
A. Electrolysis of acidified water
B. Electrolysis of Copper (II) tetraoxosulphate (VI) solution using platinum anode
C. Electrolysis of pure water
D. Electrolysis of Copper (II) tetraoxosulphate(VI) solution using Copper anode

22. This half-cell equation of reaction occurs at the--------

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$$

A. Anode B. Electrolyte C. Cathode D. Battery

23. Which of the following is not one of the uses of electrolysis?
A. Extraction of elements B. Electroplating
C. Preparation of certain important compounds D.Decomposition of impure double salts

24. Which of these arrangements is correct during the silver-plating of a table knife?
A. Cathode is knife, Anode is Silver rod, and Electrolyte is soluble silver salt;
B. Cathode is Silver rod, Anode is knife, and Electrolyte is soluble silver salt;
C. Cathode is knife, Anode is Silver rod, and Electrolyte is insoluble silver salt;

D. Cathode is Silver rod, Anode is knife, and Electrolyte is insoluble silver salt;

25. The major reason for electroplating materials is for:

A. Protection against low sales. B. Protection against effect of water.

C. Protection against corrosion. D. Protection against effect of heat.

26. In electrochemical cells, electricity is generated by a/an -----

A. Electrical change. B. Chemical change.

C. Physical change. D. Electrochemical change.

27. The only ion that is not in solution during the electrolysis of copper (II) tetraoxosulphate(vi) solution using copper anode is------

A. Cu^{2+}(aq) B. SO_4^{2-}(aq) C. O^{2-} (aq) D. H^+(aq)

28 At the cathode, which ion is preferentially discharged in the above reaction?

A. Cu^{2+}(aq) B. SO_4^{2-}(aq) C. O^{2-} (aq) D. H^+(aq)

29. The correct half-cell equation of how pure copper can be produced using electrolysis is-------

A. Cu(s) $^{-}$2e→Cu^{2+} $2e^-$→Cu(s) B. Cu(s) $^{-}$2e→Cu $2e^-$→Cu(s)

C. Cu(s) $^{-}$2e→Cu^+ $2e^-$→Cu(s) D. Cu(s) $^{-}$2e→Cu^{2+} e^-→Cu(s)

30. During the purification of elements using electrolysis, the impure element will be at the A. Cathode. B. Anode. C. Solution D. Salt

31. What is the full meaning of IUPAC?

A. International Union of Practical and Applied Chemistry

B. International Union of Practical and Accredited Chemistry

C. International Union of Pure and Applied Chemistry

D. International Union of Pure and Accredited Chemistry

32. The first two steps in the IUPAC naming of compounds are----

A. Write the oxidation number, Name the first element

B. Name the second element, Write the oxidation number

C. Name the first element, Write the oxidation number.

D. Name the first element, Change the last two letters to –ide.

What is the correct IUPAC name of the following compounds in question numbers 33–35

33. H_2SO_4

A. Tetraoxosulphate(VI) acid

B. Trioxosulphate(VI) acid

C. Tetraoxosulphate(IV) acid

D. Sulphuric acid

34. Na_2O

A. Sodium dioxide

B. Sodium oxide

C. Sodium(II) dioxide

D. Sodium(I)oxide

35. HCl

A. Hydrochloric acid

B. Hydrogen chloro-acid

C. Hydrogen chloride

D. Hydrogen(I) chloride

APPENDIX 11

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Chemistry Manipulative Skills Scale for SS2 Chemistry Students

Manipulative skills	Very Good 4	Good 3	Fairly Good 2	Fair 1
1. Rinse apparatus.				
2.Keep to drain				
3.Clamp burette firmly to the stand				
4.Keep burette straight				
5. Place the white tile on the stand.				
6.Lebel beakers: Acid(H_2SO_4) and Base(NaOH)				
7. Collect acid and base solutions from the containers with own beaker				
8. Rinse burette and pipette with right solution.				
9. Using funnel put acid into the burette up to 0 mark.				
10. Remove funnel immediately after use.				
11.With the pipette measure $25cm^3$ or $20cm^3$of base into the two or three conical flasks A, B and C.				
12. Put two drops of methyl orange indicator into the solution in the flasks.				
13. Shake gently to mix properly.				
14. Stand flask A on the tile.				
15. Note the colour change of the solution.				
16. Releasing gently the clip on burette,				

add 10cm^3 of acid to the content of the flask.				
17 Gently shaking to mix.				
18. Add 5cm^3 more of the acid, still shaking to mix.				
19. Continue the addition of the acid gently at intervals, shaking as it is added and vigilantly watching for any colour change.				
20.Stop immediately a colour change is observed.				
21.Accurately read the volume of the acid used on the burette				
22. Accept ±2cm^3 of the teacher's value.				
23. Puts up a titre table and writes both the initial and final values of acid used.				
24. Keep the flask A and content aside.				
25. Place back the funnel on the burette.				
26. Refill the burette with acid to zero mark.				
27. Place conical flask B on the white tile.				
28. Go over the titration process step by step again until the end point is reached.				
29. Do the titration two more times using the other flasks.				
30. Record the volume of acid used on the appropriate columns on the table.				
31. Add the three values of acid used.				
32. Divide by three to get the average titre value.				
33. Clean up the table and apparatus used and packed carefully.				

APPENDIX III

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Student Questionnaire for the Measurement of OTL (SQMOTL)

	STRONGLY AGREE (SA)	AGREE (A)	DISAGREE (DA)	STRONGLY DISAGREE (SD)
1. Chemistry students' notes are important to them and they guard it jealously.				
2. Chemistry students' notes are always complete and up-to-date.				
3. One Chemistry textbook is not enough for all the knowledge a student needs in the subject.				
4. Students prefer reading notebook to textbook, because the textbook is difficult to understand.				
5. Chemistry textbooks are not easily accessible to students.				
6. Most students do assignments using their friend's Chemistry textbook.				
7. Reading Chemistry textbook is not common to most students.				
8. There is only one copy of the Chemistry textbook in our library				
9. Chemistry textbooks in our school library are all outdated.				
10. The teacher does not usually give assignment that will require the use of textbook.				
11. There are not enough chairs in our library to sit and read.				
12. The Chemistry teacher is always regular in class.				
13. The Chemistry teacher is never punctual to lessons.				
14. The Chemistry teacher gives assignment once every week.				
15. Chemistry tests are done two times every term.				
16. The Chemistry teacher has never done				

Chemistry practical for us.				
17. Practical lessons are a preferred choice to the students.				
18. Practicals are done in groups in our school.				
19. Handling of every Chemistry practical apparatus is not a problem to the students.				
20. The apparatus are never always enough during practical.				
21. The laboratory attendant alone does the experiment while the students watch.				
22. The laboratory stools are not always enough.				
23. There is always water from the taps in the lab.				
24. Our predecessors did practicals several times before their WAEC examination.				
25. There is constant supply of chalk or/and whiteboard markers to the teacher.				
26. The calculation aspect of Chemistry is not taught in details for easy understanding.				
27. There is no sufficient number of desks and chairs in the class.				
28. The chalk/whiteboard is wide and in good condition.				
29. The class is always well lit.				
30. Useful educational charts are displayed on the walls of the class.				
31. Not all students have practical Chemistry note.				

APPENDIX 1VA:

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INTRODUCTION TO CHEMISTRY TREATMENT MANUAL FOR PB APPROACH

This manual is prepared to give both the students and teachers the step by step direction on how to implement the Problem-based learning approach:

The teacher explains the principles of Problem-based learning approach which is basically viewed from two dimensions, A and B;

(A). Learning chemistry in groups by focusing on specific environmental problem related to a chemistry topic, example; Water problem in a school community can be tackled under the topic 'Water' using a case-study involving SS2 chemistry students.

Vis: Since you came into this school, you have not had any water problem because your major water supply is from the state water corporation; there are also a small river and a stream not too far from the school where you could get water when it is absolutely necessary. Towards the end of your SS1, the water corporation stopped supplying you water for a reason not readily known, so, your school suffered so much water related problems. Then, the school in collaboration with the Parents Teachers Association (PTA) sunk a Borehole for you which started operating fully from your first term SS2. The following are challenges confronting you since you started using water from that borehole, how would you tackle them?

(a)

i. When you bathe with the water, your body doesn't seem to be clean, despite the fact that you would use more water than before; your body remains slimy or slippery.
ii. When washing your clothes, you would use much soap before lather is formed, and by midterm, the quantity of soap that used to last a whole term for you had already finished.

Another challenge is;

(b) If you are left to depend on the other sources of water outside the borehole, what can you do to constantly have and use clean water?

The above problems can be addressed under the following sub-topics in chemistry which are already in SS2 scheme of work but are now being used to solve the water problem in the school community.

i. Sources of water
ii. Water Treatment and
iii. Hardness of water

(B). Highlighting the common problems students encounter in the learning of particular topics in chemistry and to find out how to get around them for better understanding and performance. For example, since 2004, the NECO and WAEC Chief examiners' reports have consistently had weaknesses like; "Poor and insufficient knowledge in and exposure of candidates to practical works; Lack of understanding of International Union of Pure and Applied Chemistry (IUPAC) nomenclature; Lack of familiarity with common laboratory apparatus; Inability to relate features with functions; Inability of candidates to pay good attention to the study of chemistry; Inability to link theoretical knowledge with actual practical work; Inaccurate burette readings; Not relating real life situation to the teaching of chemistry" and so many other such topics.

APPENDIX 1VB:

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INTRODUCTION TO CHEMISTRY TREATMENT MANUAL FOR TwA APPROACH

This manual is prepared to give both the students and teachers the step by step direction on how to implement the Textbook-with-assessment learning approach. The role of the teacher as the facilitator is explicitly highlighted. Viz;

The teacher explains the principles of Textbook-with-assessment approach which is basically;

i. Emphasizing the learning and understanding chemistry topics faster by studying textbooks under minimal involvement of the teacher, and
ii. Answering the adjoining questions and exercises covering the topics, a kind of self assessment, (though the questions and exercises may still be discussed in class generally).

Procedure;

The very first lesson will be for introduction into the treatment which will be tried out there in the class by all. Vis:

Teacher introduces the lesson for the day and highlights the grey areas. He then refers the students to the textbook page of the topic to study and enlightens them on how to number the paragraphs and boxes throughout the pages covered by the topic being treated. With questions and exercises direct from the textbook, using paragraphs, boxes or/and units as the case may be, he develops the lesson. This procedure is tried out several times there in the class to allow students become familiar with the overall technique. Students are also encouraged to ask questions to clear any dilemma or confusion. The teacher will then give reading passages and corresponding questions from the textbook that will cover and prepare the students for subsequent lessons.

APPENDIX 1VC:

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INTRODUCTION TO CHEMISTRY TREATMENT MANUAL FOR PB & TwA APPROACH

This manual is prepared to give both the students and teachers the step by step direction on how to implement the Problem-based and Textbook-with-assessment learning approach as a single strategy. It is a combination of the two approaches to find out if a careful combination of the two will yield a better result than using them independently. The materials to be used will be stated and the role of the teacher as the guide/facilitator is explicitly highlighted. Vis:

The principles behind this approach is basically highlighting the principles of group-working from problem to solution and then acquisition of more knowledge through the use of textbooks as well as developing the skill of answering questions.

Procedure:

The very first lesson will be introduction to the treatment which will be tried out there in the class by all. Teacher shares the students into groups of five which they will maintain with a leader throughout the treatment period. He then introduces the lesson for the day and highlights the grey areas. He refers the students to the textbook page of the topic in study and enlightens them on how to number the paragraphs and boxes throughout the pages covered by the topic being treated. With questions and exercises direct from the textbook, using paragraphs, boxes or/and units as the case may be, he develops the lesson. He mandates the group leaders to coordinate their group members towards solving the problem on ground using both their previous notebooks, textbooks and any other textual materials at their disposal as well as their previous knowledge. This procedure is repeated there in the class to allow students become familiar with the overall technique. Students are also encouraged to ask questions to clear any dilemma or confusion. The teacher will then give reading passages and corresponding questions from the textbook that will cover and prepare the students for subsequent lesson.

APPENDIX VA

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on Problem-Based Learning Approach (TMIPBLA)

TEACHER'S MANUAL:

LESSON 1

METHOD: Problem-Based learning approach

TOPIC: Water.

SUB-TOPIC: Sources of water and Purification

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

a) Mention different sources of water

b) List characteristics of these sources of water

c) Explain how these characteristics can affect life

c) Mention various ways of purifying different types of water.

d) Describe the implications of using unpurified water.

e) State the functions of each of the chemicals used in the process of purification and removal of hardness in water.

f) State the economic importance of hard water.

INSTRUCTIONAL AIDS:

a) Samples of water from the identified water sources.

b) Sample of Alum

c) Water filter (where possible)

PROCEDURE:

STEP 1: The Teacher introduces the new strategy:

We want to explore a new method of learning chemistry for better understanding. It has been observed that majority of students do not do well in chemistry because of many reasons two of which we are going to focus on:

1. Learning chemistry without relating it to real life problems that require chemistry knowledge to solve as would be observed in the following case study, and

2. The individualistic method of learning and little or no opportunity to discuss and share with other students. This new method is called Problem-Based-learning strategy. This method encourages teamwork with colleagues in a group for exchange of knowledge in what is known as brainstorming to source solution for any real life problem related to the chemistry topic of study.

STEP 11:

The teacher assigns numbers to the students and shares them into groups of five which they should maintain throughout the treatment period. Teacher reads out the problem they are to find solution to in the form of a case study, vis: Since you came into this school, you have not had any water problem because your major water supply comes from the state water corporation, there are also a small river and a stream not too far from the school where you could get water when it is absolutely necessary. Towards the end of your SS1, the water corporation stopped supplying you water for a reason not readily known, so, your school suffered so much water related problems. Then, the school in collaboration with the PTA sunk a Borehole for you which started operating very well from your first term SS2. The following are challenges confronting you since you started using water from that borehole and as a result of the water shortage in the school, how would you tackle them?

(A) 1. When you bathe with the water, your body doesn't seem to be clean, despite the fact that you would use more water than before; your body remains slimy or slippery.

2. When washing your clothes, you would use much soap before lather is formed, and by midterm, the quantity of soap that used to last a whole term for you had already finished.

(B) If you are left to depend on the other sources of water outside the borehole, what can you do to constantly have and use clean water?

Step III:

Teacher asks the students; looking through your chemistry scheme of work or topics in your syllabus, which topics will address the above stated problems effectively?

Students respond and agree with the teacher on; Sources of water, purification methods, and hardness in water.

Step IV:

The teacher quickly guides the students to recap their SS1 lesson on water cycle and properties of water. He however states that the day's lesson will cover only sources of water and purification methods. Hardness of water will be discussed in subsequent lessons.

Step 1V:

Teacher guides the students to mention different sources of water and their characteristics, demanding contributions from each group and reward of one point for each correctly answered question or useful contribution;

i. Rain water:- It is the purest form of natural water because it is formed as a result of the condensation of water vapour in the atmosphere i.e. it is the natural form of distilled water. However, it is not clean enough for drinking due to the medium through which it is collected.

ii. Sea or Ocean- salty and dirty because it contains a lot of dissolved air and mineral salt, bacteria and organic remains. It is not good for drinking or cooking.

iii. River water- Like sea water, it is impure because of dissolved air, mineral salts and organic matter. Some shallow rivers collect so much debris from the land and empty them into the ocean or sea especially during and after rainfall. It has to be specially purified before it can be used for drinking and other domestic uses.

iv. Spring- Contains a considerable amount of mineral salt, but very little suspended impurities such as dust and bacteria. It is a good source of water, comes from rocks; cool, clean for drinking and domestic use, filtering alone can make it safe for drinking.

v. Well –It contains a lot of clay and other mineral salts. To be used for drinking or cooking, it must be sunk away from underground pollutants like pit latrines, oil-well etc. It is safer to boil the water before drinking.

vi. Borehole- It is a deeper form of well. It is less polluted than the surface well. Reasonably clean and adequate for domestic use, but if dug in an area with high deposit of calcium or Magnesium trioxocarbonate (IV) e.t.c., it will pose a different type of problem as we have in the above case study.

vii. Lake-water- It is not very clean because it is stagnant and contains a lot of decayed organic matter and bacteria.

Step V:

Teacher guides the students to suggest ways of making impure or polluted water clean for domestic use, by asking the following questions:

a) When is water said to be polluted?

b.) Mention different ways to make polluted or impure water clean for human use.

c.) Suggest what you will do if the only source of water in your surrounding is:

I. River water.

II. Sea or Ocean water.

III. Spring water.

IV. Rain water

Step VI:

Teacher guides the students in the discussion on polluted water and purification methods.

i. Water is said to be polluted when it contains impurities or pollutants like decayed organic matter, sediments, bacteria and other germs that are injurious to health.

ii. To make this water good and safe enough for domestic use, it has to be purified through the following methods; sedimentation, coagulation, filtration, disinfection, boiling, etc. Teacher guides the students to briefly explain each of these terms.

Step V11:

Students discuss in their groups the various purification methods.

CONCLUSION: Teacher collates the various contributions from the student as the concluding part of their note on the day's lesson. Teacher asks them to mention the topic for the next lesson (Hard water) and encourages the group leaders to organize discussions prior to the next lesson in order to brain-storm.

APPENDIX VB

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IBADAN, NIGERIA

Treatment Manual of Instruction on Problem-based Learning Approach (TMIPBLA)

TEACHER'S MANUAL:

LESSON 2:

TOPIC: Water,

SUB-TOPIC: Hardness in Water,

METHOD: Problem-Based learning approach

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

a) Define hardness in water and mention the two types.
b) Mention salts that cause hardness in water.
c) Demonstrate the presence of hardness in a sample of water.
d) Explain how hardness in water can be removed.
e) Explain the economic importance of hard water in life.

INSTRUCTIONAL AIDS:

a) Sample of hard water
b) Washing soap
c) Sample of calcium hydroxide
d) Sample of sodium trioxocarbonate (IV)
e) Sample of Permutit or Zeolite
f) Furred kettle or pot or boiling ring

Step 1:

HARDNESS OF WATER

Teacher introduces the sub-topic through these guiding questions;

I. What is hard water?

II. What causes it?

III. How can you demonstrate that a sample of water in bowl is hard water?

IV. Is it removable?

IV. How?

Step 11:

Teacher briefly revises the previous lesson on water purification and connects it to the lesson for the day. After a brief explanation of what hard water is the teacher gives each group a chance in turns to answer with explanation any question on the topic as the lesson progresses.

Definition and Causes of hard water;

I. Water is said to be hard when it will not form lather readily with soap.

It is water which contains a number of dissolved salts. Ordinary soap is usually sodium octadecanoate which is a soluble salt. When soap is added to hard water, the dissolved salt in the water will immediately react with the soap molecules to form an insoluble substance called scum.

II. Hard water is formed when it contains any of the following soluble salts:-Gypsum-Calcium tetraoxosulphate (V1), ($CaSO_{4}.2H_2O$); Magnesium tetraoxosulphate (VI) ($MgSO_4$); Calcium hydrogentrioxocabonate(IV) [$Ca(HCO_3)_2$] and Limestone ($CaCO_3$). It is good to note that gypsum is sparingly soluble in water but limestone is not, only if it contains carbon (IV) oxide (CO_2).

Step 111:

Demonstration of the action of hard water on;

i. Soap;

Teacher instructs the students' group heads to demonstrate the action of hard water on soap, using the items provided for the group such as one dirty napkin, washing soap, some quantity of hard water in a basin, while others watch her with keen interest. They observe how long it takes before small lather begins to be formed. Teacher asks a student to explain the chemistry of what happens up till when lather begins to form.

Explanation: Ordinary soap is sodium octadecanoate. When it is added to hard water, the dissolved salt of Calcium or Magnesium tetraoxosulphate (VI) in the water will quickly react with the soap molecules and form insoluble Calcium or Magnesium salts. This is an unpleasant scum which is difficult to rinse away from the clothes. So much soap is required to precipitate and remove these ions before the actual washing could be done which will be evidenced by the formation of much lather.

ii. Pot, Kettle or Boiling ring; The teacher displays any of these items and explains that it takes up to four or more uses before the accumulated deposit is shown.

Step 1V:

Teacher asks another question; can hardness in water be removed?

Yes, hardness in water can be removed.

Teacher leads the students to discuss, still by group contribution, the removal of hardness by first talking about the two types of hard water:-Temporary hardness and Permanent hardness in water.

a. Temporary hardness of water, causes and removal.

i. Heating;

This can easily be removed by boiling, because it is caused by the presence of dissolved calcium hydrogentrioxocarbonate (IV), $Ca(HCO_3)_2$, which decomposes on heating. The calcium trioxocarbonate (lV),$Ca(CO_3)$ formed is insoluble and this brings the calcium ion out of the solution as a precipitate. Now, the soap that is added to the water will be available for lather to form.

$Ca(HCO_3)_2(aq) \rightarrow CaCO_3(s) + H_2O(l) + CO_2(g)$

Soluble insoluble

ii. Using Slaked lime

Temporary hardness can also be removed using slaked lime $Ca(OH)_2$.

$Ca(HCO_3)_2(aq) + Ca(OH)_2(s) \rightarrow 2CaCO_3(s) + 2H_2O(l)$

soluble slightly soluble insoluble

The soluble calcium hydrogentrioxocarbonate(lV) is precipitated as the soluble calcium trioxocabonate(lV), thus removing out of the solution the calcium ions responsible for the hardness.

b. Permanent hardness, causes and removal

Causes:

This is a more serious type of hardness of water which can only be removed by using chemicals. It is caused by the presence of calcium and magnesium ions in the form of soluble tetraoxosulphate (VI) and chlorides.

Removal: The major principle is precipitating the calcium and magnesium ions from the solution. The chemical that can do it are soluble sodium compounds which will form insoluble precipitates with calcium and magnesium ions. Examples of these removal agents are caustic soda, washing soda and permutit or zeolite.

The reaction 1: Sodium trioxocarbonate (IV)(washing soda) removes these ions as insoluble calcium and magnesium trioxocarbonate (IV) respectively.

$Na_2CO_3(aq) + CaSO4(aq) \rightarrow CaCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

$Na_2CO_3(aq) + MgSO_4(aq) \rightarrow MgCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

Reaction 11: Teacher asks the students to discuss the removal using caustic soda(sodium hydroxide) and show the equations of reaction.

Caustic soda removes the calcium and magnesium ions from solution as insoluble hydroxides respectively. (equations of reaction).

Reaction (111): Permutit or Zeolite,is an ion-exchange resin used industrially and in the home for softening water. It appears naturally as sodium aluminum trioxosilicate (lV)(commonly called sodium zeolite).This can also be prepared artificially. As the hard water is passed through the resin, the sodium ions will go into the solution while the unwanted Ca and Mg ions go into the complex salt. (show the reaction)

Step V: What negative and positive effects does hard water have in our daily life?

Teacher guides the students to mention the advantages and disadvantages of hard water:

Advantages of hard water:

i. Hard water tastes better than soft water because of the dissolved minerals in it.

ii. It helps to build strong teeth and bones because of the calcium salt in it.

iii. It helps snails and crabs build their shells, also because of the calcium it contains.

iv. Hard water does not dissolve lead, so it can be supplied through lead pipes unlike soft water which does.

Disadvantages of hard water:

i. Hard water causes wastage of soap.

ii. It causes furring of kettles, pots and boilers.

iii. Calcium and Magnesium decarnoate (insoluble scum) makes white fibers look dull.

iv. Hard water cannot be used in dyeing and tanning.

G) What advice can you give on ways to take care of the negative effects and maximize the positive effects of hardness of water in the area?

Teacher allows the students to make suggestions in their groups.

Step V1:

EVALUATION:

Teacher evaluates the students' level of understanding of the lesson on hardness in water by asking the following questions:

1. When is water said to be hard?
2. When hardness is discovered in a water source, name the salts that are most likely to be present.
3. Apart from boiling, suggest three other ways hardness can be removed from water.
4. Mention two reasons why you will prefer to have hard water in your environment to soft water.
5. Give three reasons why you will never choose an area that has hard water as an only source of water supply.

CONCLUSION:

1. Teacher summarizes the entire lesson which forms the students note on the topic.

The various sources of water supply available to man are:

a) Rain water.
b) River.
c) Spring.
d) Sea / Ocean.

e) Bore-hole.

f) Pipe-borne water and

g) Lake

Not all these sources of water are clean enough for domestic use; therefore they have to be purified through these methods:

a) Coagulation (addition of potash or alum).

b) Sedimentation.

c) Filtration.

d) Disinfection (using Chlorine) and

e) Removal of hardness.

Hard water is one which does not form lather readily with soap and the salts which are responsible for this are:

a) Magnesium/Calcium chloride.

b) Calcium/Magnesium tetraoxosulphate (VI) and

c) Calcium hydrogen trioxocarbonate (IV).

{$MgSO_4$, $CaSO_4$, $MgCl_2$ and $CaCl_2$, $Ca(HCO_3)_2$ }

Hardness in water has both positive and negative effects to man;

Disadvantages:

- It causes furring on kettles, pots and boiling rings.
- It wastes a lot of soap in attempt to form lather.
- Hard water cannot be used in dying and farming; and it destroys art works like sculptures.

Advantages:

On the other hand, because of the presence of calcium salts;

- Hard water helps in the building of strong teeth and bones in children.
- It is also pleasant to drink.
- It helps snails and crabs build their shells.
- Hard water does not dissolve lead, so it can be supplied through lead pipes unlike soft water which does.

Removal of hardness of water:

This can be done in the following ways;

- By boiling, if it is temporary hardness.
- By the addition of slaked lime (Calcium hydroxide).
- By the addition of Sodium trioxocarbonate (IV).
- By the addition of Permutit (hydrated Sodium aluminum trioxosilicate (IV) or Zeolite.)

2. TAKE-HOME ASSIGNMENT:

Teacher asks the students to read up all they have done on the topic Water to prepare for a possible class test next lesson.

APPENDIX VC:

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Treatment Manual of Instruction on Problem-based Learning Approach (TMIPBLA)

TEACHER'S MANUAL

LESSON 3

METHOD: Problem-Based (PB) learning approach.

SUBJECT: Chemistry.

CLASS: SS2.

DURATION: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electrolysis of copper (II) tetraoxosulphate (VI) using copper anode.

BEHAVIOURAL OBJECTIVES:

At the end of the lesson, students should be able to:

- Define electrolysis and other common terms associated with the topic.
- State the anodic and cathodic equations during the electrolysis of copper.
- Sketch and explain the half-cell equation.
- Identify the ions in solution during the electrolysis of copper(II) tetraoxosulphate(VI).
- Explain the electrolysis of copper (II) tetraoxosulphate (VI) solution using copper anode.
- Using any other chemical salt, describe the process of electrolysis.
- Draw and explain an electrolytic cell showing the above process.

Procedure:

Step 1:

Introduction

Teacher reads out the problem to be solved to the students: Your father is a manufacturer who started producing cutleries (spoon, fork and knife) since a year ago. About six months after takeoff, the industry began to witness very low rate of sales. At close observation, they noticed gradual change to dull colour of their finished products in the warehouse, from this dull colour change to proper rusting of the items. Having completed your lessons on metals, how would the above problem be tackled under the topic electrolysis to enable you advice or suggest solution to the problem?

Step 11:

Teacher tells the students to maintain their groups and their group leader (unless they are not pleased with her/him, they can choose another quietly and quickly). He then asks the students, from your knowledge of integrated science Chemistry, which aspect of electrolysis are needed here?

Students attempted; Painting, electroplating or galvanizing.

Teacher acknowledges the students' attempts but asks them to criticize the use of paint as a solution to the problem at hand. Students make their contributions and the teacher emphasizes the temporary nature of painting. He accepts the other options but tells them that they would first do electrolysis before electroplating. He briefly goes through their previous lesson on metals and then links it to electrolysis.

Step 111:

Teacher defines electrolysis as the chemical decomposition of compound which takes place when an electric current passes through either a solution or molten form of the compound. He refreshes their mind by asking them to define these terms; cathode, anode, electrolyte, electrode etc. Teacher explains that in electrolytic reactions, there is always a half cathodic and a half anodic reaction. He asks the students to explain what Cathodic and Anodic reactions are, (reactions that occur at the cathode and anode respectively). Example, during the electrolysis of copper (ll) tetraoxosulphate(V1) solution using copper anode, the ions in solution are as follows;

	$CuSO_4$	H_2O
Cations	Cu^{2+}(aq)	H^+(aq) (cathodic reaction)
Anions	SO_4^{2-}	OH^- (anodic reaction)

Step1V:

Teacher asks the students to explain what happens at positive and negative electrodes respectively.

At the cathode (negative electrode), Cu^{2+} ion is preferentially discharged to H^+. The cathode reaction by implication is; $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$

At the anode (positive electrode), OH^- is preferentially discharged to SO_4^{2-} ion,

The anode reaction by implication is; $OH^- \rightarrow OH + e^-$

Step V:

Teacher summarizes the reactions thus;

Cathodic half reaction: $2Cu^{2+} + 4e^- \rightarrow 2Cu$

Anodic half reaction: $40H^- \rightarrow 2H_2O + O_2 + 4e^-$

Overall reaction: $2Cu^{2+} + 4OH^- \rightarrow 2Cu + O_{2\,+}\,2H_2$

STEP V1:

Teacher asks the students to discuss how pure copper can be produced using the process of electrolysis and show the accompanied half-cell equation of the reaction.

Copper will be used as anode electrode; the electrolyte will be copper (II) tetraoxosulphate (V1) solution. The anodic half equation will then be:

$Cu(s) \ ^{-2e}\!\rightarrow Cu^{2+} + \ ^{+2e}\!\rightarrow Cu(s)$

STEP V11:

Teacher uses the simple electrolytic cell diagram to explain further the above reaction.

Diagram:

EVALUATION:

- ❖ What sign does anode have?
- ❖ Through which electrode do electrons leave the cell?

- ❖ Mention the ions in the electrolyte?
- ❖ Write the anodic half equations when copper, carbon and platinum anodes are used in different electrolytic reactions.
- ❖ Which of these reactions will produce pure copper that will not lose its luster?
- ❖ Briefly explain how the impure copper at the anode becomes pure copper at the cathode.

CONCLUSION: Teacher concludes the lesson by instructing the group leaders to organize brainstorming exercise in their respective groups on electroplating to prepare for the next lesson.

APPENDIX VD:

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on Problem-based Learning Approach (TMIPBLA)

TEACHER'S MANUAL

METHOD: Problem-Based (PB) learning approach.

LESSON: 4

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electroplating or Galvanizing steel.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- List at least three uses of electrolysis
- Mention different types of iron
- Define correctly the term Electroplating
- Describe briefly how silver can be electroplated on an iron-made kitchen knife
- Give two reasons why electroplating is necessary
- Mention two other metals that could be used instead of silver and why.
- Explain why certain metals cannot be used for electroplating.
- State with examples economic importance of the process.

Procedure:

Step 1;

Teacher introduces the day's lesson by reminding the students about the problem on ground which they are trying to find solution to:-The rusting cutleries in the manufacturing industry.

Teacher guides the students to mention the uses of electrolysis, one from each group. Of all these uses, which will provide solution to the problem at hand? Electroplating,

Step 11: Teacher guides the students to define electroplating; as the electrical coating of one metal with another metal to secure improved appearance and greater resistance to corrosion. He asks more guiding questions to develop the lesson even as he awards one point score for any correctly answered question to the group as incentive.

i. Name the second most abundant metal on earth. Iron

ii. In what state does it appear naturally? Ore

iii. What process does it undergo to bring it to a useable state? Process of extraction

iv. Mention the kinds of iron produced by this method in their order of increasing purity. Pig iron→Cast iron→Wrought iron→Steel (steel is an alloy of iron and carbon)

v. Which of these is commonly used in the production of cutleries? Wrought iron

Teacher states that this is the kind that the manufacturing company uses in their production and it rusts.

vi. What is the possible remedy to this? The process of electroplating

Step 111: Teacher guides the students into the full lesson.

Armed with the knowledge of electrolysis from last lesson, let each group contribute to the procedure to carry out electroplating silver on a table knife made with wrought iron, (group leaders or whoever he/she appoints from the group are to answer the guiding questions from the teacher. If she/he misses it one person only from the group can redeem their score after which it goes to the next group and so on until the whole process is discussed.) Teacher answers any question from the students in order to carry everybody along as much as possible.

Procedure:

- ❖ The iron is first cleaned.
- ❖ Since it is a good conductor of electricity, it will be made the cathode in an electrolytic cell.
- ❖ The anode will be the pure copper, silver, gold, nickel or chromium to be deposited on the iron.

- ❖ The electrolyte will be the solution of the soluble salt of any of these metals of choice, in this case, silver.
- ❖ The circuit is then connected to allow flow of current.

Step 1V: Teacher summarizes the presentation with the diagram example of the silver plating of a table knife made of iron.

Diagram of the electrolytic cell:

Teacher describes the Process thus; when current is passed through the cell, the silver rod dissolves at the anode and the ions produced migrate through the solution to the cathode, where they are deposited as a layer on the knife. This continues until adequate quantity is deposited.

Ionic Equation;

At anode	In solution	At cathode	
$Ag_{(s)}$ e-⟶	$Ag_{(aq)}$	e-⟶	$Ag_{(s)}$

Evaluation;

Teacher mentions that it is the same procedure if any other metal like gold, chromium or nickel is to be used for the coating.

Teacher answers any question from the students or offers further explanations where necessary.

Students copy the summary note and draw the diagrams.

Teacher adds up scores and announces the best groups.

APPENDIX VE:

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on Problem-Based Learning Approach (TMIPBLA)

TEACHER'S MANUAL

METHOD: Problem-Based (PB) learning approach.

LESSON: 5

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: International Union of Pure and Applied Chemistry (IUPAC) nomenclature under Acids and Bases

SUB-TOPIC: IUPAC Nomenclature under Acids and Bases

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- State the rules for naming inorganic acid and basic.
- Identify and define acids and bases and give examples of each.
- Give the IUPAC names of binary (acids and bases) compounds correctly.
- Explain the differences between a base and an acid
- Write the correct IUPAC names of Tertiary and Quaternary Compounds

PROCEDURE:

Step 1:

Teacher states the problem to be solved this way: The Chief Examiner's report on Students' Performance in Chemistry in WAEC and NECO MAY/JUNE 2006-2008 examinations stated consistently that students had no firm (clear) understanding of the IUPAC nomenclature of compounds. Which learning approach can facilitate an easier and faster understanding by the students to improve their performance?

Step II:

Teacher instructs that students maintain their groups. He then introduces the lesson for the day as IUPAC Nomenclature. He reminds the students that one of the uses of oxidation numbers is the naming of compounds the IUPAC way. He then leads the students to recap the previous lesson on how to derive the oxidation number of elements in a compound using the following example;

Determine the oxidation number of the underlined elements in each of these compounds.

(a) $H\underline{N}O_3$ (b)$H\underline{N}O_2$ (c) $K_2\underline{Cr}_2O_7$ (d) $K\underline{Cl}O_3$

Step III:

Teacher tells the students to take note of the following remarks and tips:

-this naming of compounds will be done under acids and bases for easier understanding.

-when you are given any compound to name, the first thing to do is to quickly find the oxidation number of the metal and/or non-metal in it.

-the second is to follow the rules guiding the naming of that category of compounds step wise with optimum concentration.

-the third is to practice the naming several times starting with the simpler compounds and gradually get to the more complex ones.

-if you have difficulty naming any compound seek a prompt assistance of a group member or any other of your colleagues to put you through so as to sustain the interest for a lasting understanding.

Step IV:

Teacher encourages the students to give the definitions of acid and base:

Definitions;

- Acids are substances which when dissolve in water produces H^+ as the only positive ion in solution; the two kinds of acids are inorganic and organic acids. Our focus here will be on inorganic acids only, e.g. HCl
- A base is an oxide or hydroxide of a metal, e.g. CaO, $Zn(OH)_2$ and NaOH.

The lesson continues by naming binary compounds first. Binary compounds are compounds containing only two elements. The rules for naming the binary compounds are;

Rules:

1. The first element which may be metal –Sodium (Na), or non-metal –Hydrogen (H) or a group of elements-Ammonium (NH_4^+) is named first with no change in the name. This first element should be the less electronegative (i.e. the more electropositive) element in the compound e.g. HCl (H), NaOH (Na). {more examples given to groups and ten minutes allowed for within group interaction before coming on to the general class}. Teacher interacts further.
2. If the first element has a variable oxidation numbers e.g. Cu=+1 and +2, the oxidation number is written in Roman figure and is indicated in bracket after the name of the first element e.g. Iron (II and III), Sulphur (II and IV),{more examples given to groups and ten minutes allowed for within group interaction before coming on to the general class}.
3. The second element which is usually a non-metal and a more electronegative element is named last with its name modified to end with –ide. This is done by replacing the last 2 or 3 letters of their name by - ide, e.g. carbon as carbide, chlorine as chloride etc. e. g. HCl- hydrogen chloride, NaO-Soduim Oxide {more examples and ten minutes given to different groups to try out within the groups and then to the general class}. Teacher asks and entertains more questions to carry everybody along.
4. It is necessary to note that OH, NH_4 and CN though are made up of two elements are called radicals and are considered as single elements when present in a compound, therefore, $Ca(OH)_2$, NaCN and NH_4Cl etc are binary compounds. However, where the second element is OH, or CN, it is named Hydroxide and Cyanide respectively.
5. This systematic ending is not applicable to some binary compounds such as; water (H_2O), ammonia (NH_3), and Phosphine (PH_3). {ten minutes are given for different groups to try out more examples [$Ca(OH)_2$, $Mg(OH)_2$, NH_4Cl,NaCl etc.] within the groups and then to the general class}.

   Step V:

   Procedure for Naming of Tertiary and Quaternary Compounds; these are compounds containing more than two elements. They are –oxo-acids i.e. acids which contain oxygen atoms in their molecules and normal salts of metals. The procedures for naming them are as follows;

Rules: -Oxo-acids

1. Oxygen is named first as –oxo- with the number of atoms indicated by the Greek prefix coming first e.g.1-mono(oxo), 2- di(oxo), 3-tri(oxo) and 4-tetra(oxo).(students are encouraged to give prefix up to the number 10 in their groups)
2. The central atom which may be a metal or non-metal is then named with the ending –ate {group practice; Sulphur-[sulph-ate],carbon-[carbon-ate],Chlorine, Phosphurous, Nitrogen etc}
3. The oxidation number designated by Roman numeral comes next in bracket,{S-(VI), Nitrogen(III)etc}.
4. The word acid is finally added to the name so formed. E.g. H_2SO_4 is an –oxo-acid of a non-metal (sulphur). It is named; tetra-oxo-sulphate(VI) acid because sulphur has an oxidation number of +6.

Step V1: Teacher allows questions from students and supplies explanations

He then lists more acids to be named and allows the students to try them out in their groups and then to the general class; HNO_3, H_2SO_3, H_3PO_4, $HClO_3$, HClO, HClO and H_2CO_3.

Teacher gives an example of –oxo- acid metal as $H_2Cr_2O_7$.

Step VII: Acid radicals (oxoanions)

Acid radicals are formed by the partial or complete removal of hydrogen atoms from acids. Their names are derived from the names of the corresponding acids by replacing the ending ‘acid’ by ‘ion’. Examples; NO_3^- named tioxonitrate (V) ion, from trioxonitrate (V) acid. However, the rules here are the same as in the naming of oxo acids. More examples are given for the groups to practice with in order to consolidate;

(a) SO_4^{2-} tetraoxosulphate(VI) ion

(b) CO_3^{2-} trioxocarbonate(IV) ion

(c) HCO_3^- hydrogentrioxocarbonate (IV) ion

EVALUATION

Teacher entertains questions from students and gives them more exercises to practice with in their groups to ensure that everybody is carried along.

Using the IUPAC system of nomenclature name the following compounds

- Binary compounds; HCl, CaO, Na_2O
- -Oxo- acids; H_2SO_4, HNO_3, H_3PO_4, H_2CO_3
- Radicals; NO_2^-, MnO_4^-, $H_2PO_4^-$ and $S_2O_3^{2-}$.
- Base; $Fe_2O_{3,}$ NaOH, $Ca(OH)_2$. Fe_2O_3

APPENDIX VIA

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on TwA Learning Approach (TMITwALA)

TEACHER'S MANUAL:
LESSON 1

METHOD: Textbook-with-Assessment (TwA) learning approach

TOPIC: Water.

SUB-TOPIC: Sources of water and Purification

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

a) Mention sources of water

b) List characteristics of these sources of water

c) Explain how these characteristics can affect life

c) Mention various ways of purifying different types of water.

d) Describe the implications of using unpurified water.

e) State the functions of each of the chemicals used in the process of purification and removal of hardness in water.

f) State the economic importance of hard water.

INSTRUCTIONAL AIDS:

a) Samples of water from the identified water sources.
b) Sample of Alum
c) Water filter (where possible)

PROCEDURE:

Step 1: Introduction; We want to explore a new method of learning chemistry for better understanding. This is because it has been observed that majority of the students do not have the chemistry textbooks, even those that have do not make judicious use of them thereby acquiring limited knowledge of the subject. This new method is called 'Textbook-with-assessment learning approach'. This method encourages you to make your textbooks your closest companion and guide in your studies in order to acquire full and comprehensive knowledge of the topic. Students can make reference to any of the following chemistry textbooks but the school recommended ones for theory and practicals which everyone must always come to class with are –

1. New School Chemistry for Senior Secondary Schools, Third Edition, by Osei Yaw Ababio, and
2. New Approach; Practical Chemistry and Workbooks 1&2 by Eketunde, O. A. & Ore, B. E.

These ones are optional:

1. Tonad Essential Chemistry for Senior Secondary Schools, by I. A. Odesina.
2. Senior Secondary Chemistry, Textbook 2, by S.T. Bajah,B.O. Teibo, G. Onwu, A. Obikwere.
3. Fundamental PHYSICAL Chemistry, Edited by Keinde Okonjo.
4. Modern-Day Chemistry for SS1-SS3 & Higher schools, by Sanda, O. E.

Step 11:

1. Teacher explains how the approach is implemented, thus: This is the very first lesson; we shall do the preambles to familiarize ourselves with the new learning method. Everybody must be fully involved and carry out every step of the instruction given to the later, if not the person will miss out.
2. Teacher instructs students to bring out their textbook-"Ababio" or whichever text is recommended by the school, a coloured pencil or marker to number the paragraphs for easier identification.
3. Teacher and the students do the counting and numbering together. {Please note these important remark & abbreviations; (i) this paragraph numbering is done

only on the first day of the lesson on any new topic, for subsequent lessons, references are made on the existing numberings.

(ii) Teacher mentions the first page of the topic of study and counts the first paragraph as number 1, the next paragraph as 2 as the students note it down in their individual texts and it goes on like that until they get to where the topic ends.

(iii) Tables and Figures are accepted and referred to as they are originally given by the author.

(iv) Page=p., Pages=pp.; Paragraph=pgf., Reference=ref.}.

4. The topic for the day is introduced and the key areas highlighted by the teacher.
5. He gives textbook references in pages and paragraphs based on the short-answer-questions and exercises on the topic of study.
6. Textbook is read through and answers to the questions picked out by the students from the passages through instructions and brief explanations by the teacher for about 20minutes. The content of the topic becomes clearer and understanding easier as the lesson progresses.

Teacher allows for questions from the students for further clarity.

Step 111: Lesson Delivery

WATER; Sources and purification of water, Ababio p.269

The teacher quickly guides the students to recap their SS1 lesson on water cycle and properties of water.

Step 1V:

Teacher highlights these key areas and gives brief explanation on them;

a. Different sources of water. p.269; pgf.2
b. Their characteristics. P.269; pgfs.2,3,4.
c. The cause of their impurity and p.269; pgfs.2,3,4
d. Purification methods. p. 269; pgf. 9

Step V: As the lesson develops, to ensure firm grasp and usage of the referencing and paragraph numbering, teacher instructs the students to:

Open the textbook (Ababio) to ref. p. 269 and do the following small exercise.

Mention the sub-topic and headings on pgfs. 1, 5 and 8; (Answer: Natural and Treated Water, Treated Water and Water supply to a township.) Corrections are made for those who did not get it right.

For more trial exercise, teacher gives the students fifteen minutes to read through paragraphs 1-3 the same page, and answer the adjoining assessment questions in their jotters.

QUESTIONS and EXERCISES:

Complete the following sentences in numbers i, ii, and iii; then answer the rest of the questions:

i. One of the most common substances known is--------
ii. It is a good ----for many substances and rarely occurs in its-----form in nature.
iii. The impurities present in spring water, though in little quantities are----and---
iv. Rain water is the purest form of natural water: True or False?
v. Give a reason to support your answer.
vi. Which source of water contains a lot of clay?
vii. In addition to clay, what else is present in this source of water?
viii. On pgf 2, mention two precautions that must be taken when siting well that will be used as a source of drinking water.
ix. Mention three examples of natural sources of water that contains lots of dissolved air, mineral salts, bacteria and organic remains.
x. How can water from these sources be made clean enough for drinking?

Step VI: Teacher instructs the students to exchange their jotters and score accordingly as he leads them to pick out the answers from the referenced passages. Teacher then collects the marked jotters and records the scores.

Step V1I: Conclusion:

Teacher summarizes the day's lesson thus; Water is one of the most common substances in nature because it is a good solvent for many substances. So far as we have seen, there are two major types of water: Natural and Treated water. Natural sources include rainwater, spring water, well-water, river water, lake water and sea-water. Each of these sources has its characteristics and levels of purity for domestic use.

i. Rain water:- It is the purest form of natural water because it is formed as a result of the condensation of water vapour in the atmosphere i.e. it is the natural form of distilled water. However, it is not clean enough for drinking due to the medium through which it is collected.

ii. Sea or Ocean- salty and dirty because it contains a lot of dissolved air and mineral salt, bacteria and organic remains. It is not good for drinking or cooking.

iii. River water- Like sea water, it is impure because of dissolved air, mineral salts and organic matter. Some shallow rivers collect so much debris from the land and empty them into the ocean or sea especially during and after rainfall. It has to be specially purified before it can be used for drinking and other domestic uses.

iv. Spring Water- Contains a considerable amount of mineral salt, but very little suspended impurities such as dust and bacteria. It is a good source of water, comes from rocks; cool, clean for drinking and domestic use.

v. Well Water –It contains a lot of clay and other mineral salts. To be used for drinking or cooking, it must be sunk away from underground pollutants like pit latrines, oil-well etc. It is safer to boil the water before drinking.

vi. Lake-water- It is not very clean because it is stagnant and contains a lot of decayed organic matter and bacteria.

vii. Borehole Water- It is a deeper form of well. It is less polluted than the surface well. Reasonably clean and adequate for domestic use, but if dug in an area with high deposit of calcium or Magnesium trioxocarbonate (IV) e.t.c., it will pose a different type of problem which is one of the sub-topics to be done next lesson. However, all the natural sources of water have to be purified and treated in order to ensure high standard purity for most domestic uses.

IMPORTANT REMARK: Please note that subsequent lessons will not involve students reading textbook in the class. The aim of the reading assignment is to enable the students prepare by reading ahead of the lesson. Teacher will deliver the subsequent lessons as a deductive discussion with the students who supposedly would have read the given textbook references and should be ready to be active participators instead of passive *listeners. The reading assignment doubles as, a lesson plan outline for the teacher and reading assignment for the students to prepare for the lesson.*

Any reference to the textbook as the lesson progresses will be at the discretion of the teacher where it is absolutely necessary. But students are free to consult their textbooks in class while the lesson is going on especially as the assessment questions are being scored.

Step VIII. Teacher gives the reading assignment and the assessment questions to students to prepare them for next lesson:

a. Read from pgf.5; p 269; heading-Treated Water to pgf. 26; p. 272; heading-Disadvantages of Hard water

b. Supply answers to the following questions and exercises as you read on.

1) The second major type of water after the natural water is--------
2) Mention three specially prepared examples of this type of water.
3) Which of these three is the chemically pure water?
4) Name four uses of this water as mentioned on the passage.
5) Complete this sentence: Pipe-born water is prepared in a-------
6) Under what heading is the above sentence?
7) Mention the various stages of water purification in the water-treatment plant.
8) If you use water from deep well or borehole to wash and lather did not form readily with soap, what kind of water is that?
9) Mention the three salts on p.270, pgf 11, one of which can be found in that kind of water.
10) What is scum?
11) Write the chemical formula of gypsum
12) What happens to $Ca(HCO_3)_2$ when the water is heated?
13) Which ion needs to be removed before the water can form lather easily?
14) Read pgf 17, p.271, and copy out the last 8 words there.
15) On Experiment 16.1 box, p. 271, which processes are you instructed to repeat on pgf 3(box)?
16) In one sentence, explain what stalagmites and stalactites mean

17) Mention three chemicals that can be used to remove permanent hardness in water.

18) Copy out clearly as it is on p. 272, the equation of reaction between caustic soda and Magnisuim ion in the removal of permanent hardness of water.

19) Soduim zeolite occurs in nature as--------?

20) Is there any economic importance found in hard water?

21) Mention three of each.

APPENDIX VIb

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA
Treatment Manual of Instruction on TwA Learning Approach (TMITwALA)

TEACHER'S MANUAL:
LESSON 2

METHOD: Textbook-with-Assessment (TwA) learning approach.

SUB-TOPIC: Purification and Hardness in Water

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

f) Mention various stages of purification of water in a treatment plant.

g) Define hardness in water and mention the two types.

h) State the difference between temporary and permanent hardness in water.

i) Mention salts that cause hardness in water.

j) Explain how hardness in water can be removed.

k) Explain the effects of hard water in life.

INSTRUCTIONAL AIDS:

g) Sample of hard water

h) Washing soap

i) Sample of calcium hydroxide

j) Sample of sodium trioxocarbonate (IV)

k) Sample of Permutit or Zeolite

l) Furred kettle or pot or boiling ring

Step1. Introduction: Teacher guides the students in the discussion on polluted water and purification methods.

Water is said to be unclean or polluted when it contains impurities or pollutants like decayed organic matter, sediments, bacteria and other germs that are injurious to health.

To make this water good and safe enough for domestic use, it has to be purified. Mention the different methods of purification?

Response: sedimentation, coagulation, filtration, disinfection, distillation, boiling, most often through the use of water treatment plant etc.

Step II. Teacher guides the students to briefly discuss each of these terms, (see also Separation techniques, Ababio, pp.12, 13 and14 for more useful information). For borehole and other sources of hard water, he says, a different method is required, which is removal of the hardness in water.[Ref. text; Ababio;p. 270, pgf 11].

Step III: Teacher refers the students to the reading assignment given to them from the previous lesson and asks them to exchange their jotters for subsequent scoring as the lesson goes on. The reading assignment was based on:

a. Water purification and treatment methods, and

b. Hardness in water.

Step IV. Through deductive questioning and occasional reference to the textbook and the assessment questions, teacher continues to deliver his lesson for the day with active participation of the students especially as they are scoring the assessment questions.

Step V. Discussion on examples and uses of treated water:

1) Distilled water
2) Pipe borne water for townships
3) Chlorinated water for use in swimming pools.

Step V1. Having discussed the above headings, teacher refers the students to the assessment questions to score the related ones (questions 1-7).

Step VI1. Hardness in water: Teacher leads the students in further discussion on the following headings;

1. Origin of Hard Water
2. Types of Hard Water
    i. Temporary hardness
    ii. Permanent hardness

3. Removal of temporary hardness

4. Effect of temporary hard water;

i. (Demonstration of hardness in water using dirty napkin, washing soap and hard water all in a basin.)

ii. (Display of boiling-ring, kettle or pot showing the effect of hard water on them).

Step VII1. Teacher refers the student back to the assessment questions to score the areas covered so far (questions 8-16).

Step 1X. Teacher continues the lesson as the class discusses;

5. Permanent Hardness

i. Causes and

ii. Removal methods

6. Economic importance of hard water discussed as advantages and disadvantages of hard water in life.

Step X.

Conclusion: Teacher directs students back to score the last segment of the assessment questions and then summarizes the day's lesson which forms the students' note.

STUDENTS' NOTE

I. Hard water is the water which does not form lather readily with soap.

It is water which contains a number of dissolved salts. Ordinary soap is usually sodium octadecanoate which is a soluble salt. When soap is added to hard water, the dissolved salt in the water will immediately react with the soap molecules to form an insoluble substance called scum.

II. Hard water is caused by any of the following soluble salts:-Gypsum-Calcium tetraoxosulphate (V1), ($CaSO_4.2H_2O$); Magnesium tetraoxosulphate (VI) ($MgSO_4$); Calcium hydrogentrioxocabonate (IV) [$Ca(HCO_3)_2$] and Limestone ($CaCO_3$). It is good to note that gypsum is sparingly soluble in water but limestone is not, only if it contains carbon (V1) oxide (CO_2).

Demonstration of the action of hard water and soft water on soap:

To demonstrate the action of hard water and soft water on soap the following items can be used; dirty napkin or handkerchief, washing soap, some quantity of hard and soft water in basins on a table. Students are asked to come out to practicalise it.

Observation: They observe that it takes a longer time for lather to form when washing with hard water than with the soft water.

Explanation: To explain the Chemistry of what happens up till when lather begins to form in both cases, it goes thus;

Ordinary soap is sodium octadecanoate. When this is added to hard water, the dissolved salt of Calcium or Magnesium tetraoxosulphate (VI) in the water will quickly react with the soap molecules and form insoluble Calcium or Magnesium salts. This is the unpleasant scum which sticks to the clothes and is difficult to rinse away. So much soap is required to precipitate and remove these ions before the actual washing begins. For the soft water, there is no dissolved salt, so the octadecanoate reacts with the water straight away to form lather which cleans the dirt.

Removal of Hardness in Water:

There are two types of hard water; Temporary and Permanent hard water. Since their chemical formation is different, their removal methods are also different.

Temporary hardness; causes and removal

Temporary hardness is caused by the presence of dissolved calcium hydrogentrioxocarbonate (IV), $Ca(HCO_3)_2$. This can easily be removed by boiling because $Ca(HCO_3)_2$ is easily decomposed on heating. The calcium trioxocarbonate(lV) ,$Ca(CO_3)$ formed is insoluble and this brings the calcium ion out of the solution as a precipitate. Now, the soap that is added to the water will be available for lather to form.

$Ca(HCO_3)_2(aq) \xrightarrow{boil} CaCO_3(s) + H_2O(l) + CO_2(g)$

Soluble insoluble

Removal using Slaked lime

Temporary hardness can also be removed using slaked lime $Ca(OH)_2$.

$Ca(HCO_3)_2(aq) + Ca(OH)_2(s) \rightarrow 2CaCO_3(s) + 2H_2O(l)$

soluble slightly soluble insoluble

The soluble calcium hydrogentrioxocarbonate(lV) is precipitated as the insoluble calcium trioxocabonate(lV), thus removing out of the solution the calcium ions responsible for the hardness.

Permanent hardness; causes and removal

Causes:

This is a more serious type of hardness of water which can only be removed by using chemicals. It is caused by the presence of calcium and magnesium ions in the form of soluble tetraoxosulphate(VI) and chlorides.

Removal: The major principle is precipitating the calcium and magnesium ions from the solution. The chemical that can do it are soluble sodium compounds which will form insoluble precipitates with calcium and magnesium ions. Examples of these removal agents are caustic soda, washing soda and permutit or zeolite.

The reaction i: Sodium trioxocarbonate(IV)(washing soda) removes these ions as insoluble calcium and magnesium trioxocarbonate (IV) respectively.

$Na_2CO_3(aq) + CaSO4(aq) \rightarrow CaCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

$Na_2CO_3(aq) + MgSO_4(aq) \rightarrow MgCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

Reaction ii: Removal of hard water using caustic soda (sodium hydroxide) and show the equations of reaction.

Caustic soda removes the calcium and magnesium ions from solution as insoluble hydroxides respectively. (equations of reaction).

Reaction iii: Permutit or Zeolite,is an ion-exchange resin used industrially and in the home for softening water. It appears naturally as sodium aluminum trioxo silicate (lV)(commonly called sodium zeolite).This can also be prepared artificially. As the hard water is passed through the resin, the sodium ions will go into the solution while the unwanted Ca and Mg ions go into the complex salt. (show the reaction)

Negative and positive effects of hard water in our daily life

Teacher guides the students to mention the advantages of hard water:

i. Hard water tastes better than soft water because of the dissolved minerals in it.
ii. It helps to build strong teeth and bones because of the calcium salt in it.
iii. It helps snails and crabs build their shells, also because of the calcium it contains.

iv. Hard water does not dissolve lead, so it can be supplied through lead pipes unlike soft water which does.

Disadvantages of hard water:

i. Hard water causes wastage of soap.

ii. It causes furring of kettles, pots and boilers.

iii. Calcium and Magnesium decarnoate (insoluble scum) makes white fibers look dull.

iv. Hard water cannot be used in dyeing and tanning.

Step X1. Teacher then gives another set of reading assignment on the topic for next lesson.

READING ASSIGNMENT: TOPIC: ELECTROLYSIS

The headings to cover under this topic are;

1. Introductory lesson on electrolysis including definition of basic terms used in the process.
2. Some examples of electrolysis e.g.

   i. Electrolysis of Copper (II) tetraoxosulphate (VI) solution using different anodes.

3. Uses of electrolysis e.g.

   i. Extraction and purification of metals and

   ii. Electroplating

Textbook references are; Electrolysis-definition of terms; “Ababio”, p.186, pgfs. 1-7, including box-:fig.11.18, Simple electrolytic cell.

APPENDIX V1C

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Treatment Manual of Instruction on TwA Learning Approach (TMITwALA)

LESSON 3

METHOD: Textbook-with-Assessment (TwA) learning approach.

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electrolysis of copper (II) tetraoxosulphate (VI) using copper anode.

BEHAVIOURAL OBJECTIVES:

At the end of the lesson, students should be able to:

- Define electrolysis, cathode, anode, cathodic and anodic reactions etc
- State the anodic and cathodic equations during the electrolysis of copper.
- Identify the ions in solution during the electrolysis of copper(II) tetraoxosulphate(VI).
- Explain the electrolysis of copper(II) tetraoxosulphate(V1) solution using copper anode.
- Draw and explain an electrolytic cell showing the above process.
- Explain the effect of electrolysis on any other salt.

Procedure:

Step 1:

Introduction

Teacher briefly goes through their previous lessons on metals as good conductor of electricity and electrons producers to link it to electrolysis, thus; in electrochemical cells, electricity is generated by a chemical change. The reverse is also possible, which means electric current can be used to bring about a chemical change.

Step 11: Teacher gives the students a ten minutes exercise to do in their jotters in other to ascertain those who actually did the reading assignment:

1. From which paragraph on p.186 was the underlined passage lifted?

2. Define the following terms; electrolysis, electrodes, electrolytes, cathode, anode and electrolytic cell.

Step 111: a). Teacher guides the students to define the above listed terms as they exchange their jotters to score. Electrolysis is the chemical decomposition of compound which takes place when an electric current passes through either a solution or molten form of the compound (definition of the other terms are given and scored also).

b). He went further to explain that in electrolytic reactions, there is always a half cathodic and a half anodic reaction. He asks the students to explain what cathodic and anodic reactions mean.

Answer: (Students made contributions and the teacher explains further)Cathodic and Anodic reactions are reactions that occur at the cathode and anode respectively. Example, during the electrolysis of copper (II) tetraoxosulphate(V1) solution using copper anode, the ions in solution are as follows;

	$CuSO_4$	H_2O
Cations	Cu^{2+}(aq)	H^+(aq)
Anions	SO_4^{2-}	OH^-

Step1V:

c). Teacher explains what happens at negative electrode and asks the students to explain the reactions on the positive electrode.

At the cathode (negative electrode), Cu^{2+} ion is preferentially discharged to H^+. The cathode reaction by implication is; $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$

At the anode (positive electrode), OH^- is preferentially discharged to SO_4^{2-} ion,

The anode reaction by implication is; $OH^- \rightarrow OH + e^-$

d). Teacher summarizes the reactions thus;

Cathodic half reaction: $2Cu^{2+} + 4e^- \rightarrow 2Cu$

Anodic half reaction: $40H \rightarrow 2H_2O + O_2 + 4e^-$

Overall reaction: $2Cu^{2+} + 4OH^- \rightarrow 2Cu + O_{2\,+}\,2H_2$

Step V:

e). Teacher leads the students to discuss how pure copper can be produced using the process of electrolysis and the accompanied half-cell equation of the reaction.

Copper will be used as anode electrode during the electrolysis of copper (II) tetraoxosulphate (V1) solution. The anodic half equation will then be:

$$Cu(s)\ ^{-2e}\rightarrow Cu^{2+}\ ^{+2e}\rightarrow Cu(s)$$

Step V1: Summary and Evaluation

Teacher uses the simple electrolytic cell diagram to explain further the above reaction and asked the following questions as oral quiz as he concludes the day's lesson.

- ❖ What sign does anode have?
- ❖ Through which electrode do electrons leave the cell?
- ❖ Mention the ions in the electrolyte?
- ❖ Mention the anodic half equations when copper, carbon and platinum anodes are used in different electrolytic reactions.
- ❖ Which of the above reactions will produce pure copper that will not lose its luster?
- ❖ Briefly explain how the impure copper at the anode becomes pure copper at the cathode.

Diagram:

Conclusion:

Teacher gives reading assignment and the assessment questions based on the topic for the next lesson.

i. Name the second most abundant metal on earth. Iron

ii. In what condition does it appear naturally? Ore

iii. What process does it undergo to bring it to a useable state? Process of extraction

iv. Mention the kinds of iron produced by this method in their order of increasing purity. Pig iron→Cast iron→Wrought iron→Steel (steel is an alloy of iron and carbon)

v. Which of these is commonly used in the production of cutleries? Wrought iron

vi. Teacher states that this is the kind of iron that most manufacturing companies use in the production of certain products like cutleries and it is bound to rust.

vii. What is the possible remedy to this? The process of electroplating

Study carefully;

(a) Uses of electrolysis

(b) Extraction and purification of metals and

© Electroplating.

APPENDIX VID:

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Treatment Manual of Instruction on TwA Learning Approach (TMITwALA)

TEACHER'S MANUAL

LESSON 4

METHOD: Textbook-with-Assessment (TwA) learning approach.

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electroplating or Galvanizing steel.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- List at least three uses of electrolysis
- Mention different types of iron
- Define correctly the term Electroplating
- Describe briefly how silver can be electroplated on iron
- Give two reasons why electroplating is necessary
- Mention two other metals that could be used instead of silver.

Procedure:

Step 1;

Teacher asks the students to mention the uses of electrolysis. Of all these uses, the day's lesson will focus on Electroplating as being important in rusting prevention.

Step II: Teacher guides the students to define electroplating; as the electrical coating of one metal with another metal to secure improved appearance and greater resistance to corrosion. He asks more guiding questions to develop the lesson.

Step III: Teacher guides the students into the full lesson.

Armed with the knowledge of electrolysis from last lesson, students are asked to discuss the procedure to carry out electroplating on iron.

Procedure:

- ❖ The iron is first cleaned.
- ❖ Since it is a good conductor of electricity, it will be made the cathode in an electrolytic cell.
- ❖ The anode will be the pure copper, silver, gold, nickel or chromium to be deposited on the iron.
- ❖ The electrolyte will be the solution of the soluble salt of any of these metals of choice.

Step 1V: Teacher summarizes the presentation with a diagram example of silver plating of a table knife made of iron.

- ❖ The cathode is the table knife.
- ❖ The anode is a pure silver rod.
- ❖ The electrolyte is a solution of silver trioxonitrate (V)

Process; when current is passed through the cell, the silver rod dissolves at the anode and the ions produced migrate through the solution to the cathode, where they are deposited as a layer on the knife.

Ionic Equation; Teacher asks the students to write the ionic equation of the reaction in their jotter. He goes round to score for those who got it right and give follow up explanation others.

At anode	In solution	At cathode
$Ag_{(s)}$ e-⟶	Ag $_{(aq)}$	e-⟶ $Ag_{(s)}$

Step V: Diagram of electrolytic cell

Step VI: Evaluation;

Teacher answers any question from the students or offers further explanations where necessary.

Students copy the summary note and draw the diagrams.

Step VII: Teacher gives reading assignment and assessment questions to prepare for next lesson by referring them to book one of New Approach Practical chemistry and Workbook (Eketunde) pp.60-64, pgfs 1-19 as follows:

1. What is the oxidation number of Chlorine, Oxygen and Calcium in each of these compounds; CaH_2, H_2O_2 and NaCl.
2. Give the definition of acid, base and salt
3. What is the full meaning of this Acronym IUPAC?
4. Should all compounds made up of two elements be called binary compounds?
5. Support your answer with at least two examples.
6. State the first three rules in the naming of binary compounds.
7. Show the end product of these elements: Bromine, Chlorine, Hydride, Oxygen; when –ide is added to transform them.
8. What are binary compounds?
9. Give 3 examples.
10. Which category of compounds is described as Tertiary compounds?
11. Give 3 examples.
12. State the third rule in the naming of tertiary compounds.
13. Describe the position of oxidation number of an element in the naming of tertiary inorganic compounds.
14. Give 2 examples.

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Treatment Manual of Instruction on TwA Learning Approach (TMITwALA)

TEACHER'S MANUAL
LESSON 5

METHOD: Textbook-with-Assessment (TwA) learning approach.

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: IUPAC Nomenclature of compounds.

SUB-TOPIC: IUPAC Nomenclature under Acids and Bases.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- Identify and define acids and bases with examples
- State the rules for naming inorganic compounds and
- Give the IUPAC names of the compounds (acids and bases) correctly.

PROCEDURE:

Step 1:

Teacher states the topic of study as; International Union of Pure and Applied Chemistry (IUPAC) nomenclature of compounds. This topic will be taught using TwA approach.

Step II;

Teacher continues with the TwA strategy and leads the students to number the pages and paragraphs of the appropriate sections of the textbook. He introduces the lesson for the day as IUPAC Nomenclature of compounds and writes it on the board. He leads the students to recap the previous lesson on how to derive the oxidation number of elements in a compound using the following examples;

(a) $H\underline{N}O_3$ (b)$H\underline{N}O_2$ (c) $K_2\underline{Cr_2}O_7$ (d) $K\underline{Cl}O_3$

Determine the oxidation number of the underlined elements in each of these compounds (Ref. Eketunde, p.60, pgfs 1-4……)

Teacher reminds the students that one of the uses of oxidation numbers is the naming of compounds using the new IUPAC system.

Step III:

Teacher calls the attention of the students to the following remarks and Tips:

-this naming of compounds will be done under acids, bases and salts for easier understanding.

-when you are given any compound to name, the first thing to do is to quickly find the oxidation number of the metal and/or non-metal in it, especially if any of the elements has variable oxidation numbers.

-the second is to follow the rules guiding the naming of that category of compounds step wise with optimum concentration.

-the third is to practice the naming several times, starting with the simpler compounds and gradually get to the more complex ones.

-if you have difficulty naming any compound seek a prompt assistance of your colleagues to put you through, using the textbook references and following the rules stepwise.

Step 1V:

Acids: Teacher asks the students; what is an acid? Students make attempts.

Definition; Acids are substances which when dissolve in water produces H^+ ion as the only positive ion in solution. Of the two kinds of acids; Inorganic and Organic acids, the focus will be on inorganic acids. What is a base? A base is an oxide or hydroxide of a metal, e.g. CaO, $Zn(OH)_2$ and NaOH. Bases are named as binary compounds. Teacher explains further that the rules for their naming are also the same as with acids but bases end in oxide or hydroxide.

(a) Binary compounds; Teacher asks the students to define what binary compounds are: They are compounds that contain only two elements; a few acids and bases fall into this group. Teacher makes the students state the rules for naming binary compounds from the textbook references given, thus;

Rule 1: The first element, which may be metal or non-metal but the less electronegative (i.e. the more electropositive) element is named first with no change in the name; Eketunde, p.61,pgf 6

Rule 2: If the first element has variable oxidation numbers e.g. Cu=1 & 2, Fe=2 & 3, N=1-5 etc., the oxidation number of the element is written in Roman figure in brackets after the name of that first element e.g. Iron (II), Cu (I), Sulphur(IV); Eketunde, p.61, pgf 7.

Rule 3: Teacher instructs all students to state rule 3 out loud from p.62, pgf 8 together {The second element which is usually non-metal is named by replacing the last 2 or 3 letters of their name by letters –ide. These are the more electronegative elements. E.g. Chlor(ine)=Chlor(ide), Sulph(ur)=Sulph(ide), Oxygen=(oxide). HCl named hydrogen chloride; CaCl, (calcium chloride), NaBr (sodium bromide), $FeCl_3$ [Iron(111)Chloride]etc. Teacher refers them to p.61,pgfs 6-8 for more examples and allows them more time to practice

Examples	IUPAC Name
Fe_2O_3	Iron (III) oxide
NaOH	Sodium hydroxide
$Zn(OH)_2$	Zinc hydroxide

Teacher further states that the systematic ending is not applicable to some binary compounds such as; water (H_2O), ammonia (NH_3), and phosphine (PH_3).

Step V: Another group of elements that attract attention are called radicals. They are treated as single elements while naming their compounds; e.g. ammonium ($NH4^+$), hydroxide (OH^-) and cyanide (CN^-) even though they are made up of two elements. Teacher treats some examples and then asks the students to name the following; $Ca(OH)_{2,}$ $Mg(OH)_{2,}$ NH_4Cl, Cu_2O etc. Teacher refers students to the assessment questions and leads them to score up to the areas covered so far.

Step VI:

(b) Tertiary Compounds; these are compounds containing three elements e.g. $CaCO_3$.Teacher asks a student to identify the three elements in this compound: Referring the students to pp.62-63, pgfs 10-14, he guides them through the naming of tertiary inorganic compounds. Some common examples are –oxo-acids i.e. acids which contain oxygen atoms in their molecules. The procedure for the naming is done as follows by the students from the reading assignment they did;

Rules:

1. Oxygen is named first as –oxo- with the number of atoms indicated by the Greek prefix mono –(1), di-(2), tri-(3) and tetra-(4).

2. The central atom which may be a metal or non-metal is then named with the ending –ate and its oxidation number designated by Roman numeral in bracket.
3. The word acid is finally added to the name so formed. E.g. H_2SO_4 is an –oxo-acid of a non-metal (sulphur). It is named; tetra-oxo-sulphate(vi) acid because sulphur has an oxidation number of +6.

Teacher allows questions from students and supplies explanations. He then lists more acids to be named and allows the students to try them out in the general class until majority of the students are able to name the compounds; HNO_3, H_2SO_3, H_3PO_4, $HClO_3$, $HClO_3$, $HClO$ and H_2CO_3.

Teacher gives an example of –oxo- acid metal as $H_2Cr_2O_7$ and asks a student to try the naming.

Step VII: Acid radicals (oxoanions or Poly atomic ions)

Teacher points out that the rules for naming acids are the same as in naming oxoanions; (pp.65,pgfs 20-23) , the only difference is that acid radicals are formed by the partial or complete removal of hydrogen atoms from acids. Their names therefore are derived from the names of the corresponding acids by replacing the ending 'acid' by 'ion'. Examples; NO_3^- named tioxonitrate(V) ion, from trioxonitrate(V) acid. More examples for the students to practice and consolidate on are;

(a)	SO_4^{2-}	tetraoxosulphate(V1) ion
(b)	CO_3^{2-}	trioxocarbonate(1V) ion
(c)	HCO_3^-	hydrogentrioxocarbonate(1V) ion
(d)	HSO_4^-	hydrogentetraoxosulphate(V1) ion

EVALUATION

Teacher entertains questions from students and gives them more exercises to practice with on their own to ensure that everybody is carried along.

Using the IUPAC system of nomenclature name the following

- Binary compounds; HCl, CaO, Na_2O
- -Oxo- acids; H_2SO_4, HNO_3, H_3PO_4, H_2CO_3
- Radicals; NO_2^-, MnO_4^-, $H_2PO_4^-$ and $S_2O_3^{2-}$.
- Bases; CaO, $Zn(OH)_2$, NaOH and Fe_2O_3

APPENDIX VI1A

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on PB &TwA Learning Approach (TMIPBTwALA)

TEACHER'S MANUAL:

LESSON 1

METHOD: Problem-Based and Textbook-with-Assessment learning (PB & TwA) approach

TOPIC: Water.

SUB-TOPIC: Sources of water and Purification

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

a) Mention different sources of water
b) List characteristics of these sources of water
c) Explain how these characteristics can affect life.
d) Identify the various causes of impurity.
e) Mention various ways of purifying different types of water.
f) Describe the implications of using unpurified water.
g) State the functions of each of the chemicals used in the process of purification and removal of hardness in water.
h) State the economic importance of hard water.

INSTRUCTIONAL AIDS:

a) Samples of water from the identified water sources.
b) Sample of Alum
c) Water filter (where possible)

PROCEDURE:

Step 1:

Teacher introduces the new method; We want to introduce a new method of learning chemistry for better understanding. This is because it has been observed that majority of the students do not have the chemistry textbooks, even those that have do not make judicious use of them thereby acquiring limited knowledge of the subject. Secondly, most students do not relate chemistry topics to everyday living and as such cannot solve any real life problem with the knowledge acquired from it thereby making the subject look so abstract and difficult. This new method, Problem-based and Textbook-with-assessment learning approach will encourage you to make your textbooks your closest companion and guide in your studies. Secondly, brainstorming in groups to find solution to a real life problem under a related chemistry topic produces better understanding and easy retention of knowledge.

Students can make reference to any of the following Chemistry textbooks but the school recommended ones for theory and practicals which everyone must always come to class with are –

1. New School Chemistry for Senior Secondary Schools, Third Edition, by Osei Yaw Ababio, and
2. New Approach; Practical Chemistry and Workbooks 1&2 by Eketunde, O. A. & Ore, B. E.

   The following ones are optional:
3. Tonad Essential Chemistry for Senior Secondary Schools, by I. A. Odesina.
4. Senior Secondary Chemistry, Textbook 2, by S.T. Bajah,B.O. Teibo, G. Onwu, A. Obikwere.
5. Fundamental PHYSICAL Chemistry, Edited by Keinde Okonjo

Step II:

Teacher explains how the approach is implemented. This is the very first lesson; we shall do the preambles to familiarize ourselves with the new learning method. Everybody must be fully involved and carry out to the later every step of the instruction given, if not you will miss out.

Procedure: i. Teacher assigns numbers to the students and shares them into groups of five which they should maintain throughout the treatment period.

ii. Teacher reads out the problem they are to find solution to in the form of a case study, thus: Since you came into this school, you have not had any water problem because your major water supply comes from the state water corporation. There are also a small river and a stream not too far from the school, where you could get water when it is absolutely necessary. Towards the end of your SS1, the water corporation stopped supplying you water for a reason not readily known, so, your school suffered so much water related problems. Then, the school in collaboration with the PTA sunk a Borehole for you which started operating very well from your first term SS2. The following are challenges confronting you since you started using water from that borehole. How would you tackle these problems?

(A)1. When you bathe with the water, your body doesn't seem to be clean, despite the fact that you would use more water than before; your body remains slimy or slippery.

2. When washing your clothes, you would use much soap before lather is formed, and by midterm, the quantity of soap that used to last a whole term for you had already finished.

Another challenge is;

(B) If you are left to depend on the other sources of water outside the borehole, what can you do to constantly have and use clean water?

Step III:

Teacher asks the students; looking through your chemistry scheme of work, which topics will address these problems effectively?

Students respond and agree with the teacher on; Sources of water, purification methods, and hardness in water.

Step IV:

Teacher explains to the students that this first lesson will only cover sources of water, characteristics and purification methods; hardness in water will be treated in the next lesson. The topic for the day is introduced. He then quickly guides the students to recap their SS1 lesson on water cycle and properties of water. Connecting back to the topic for the day, the key areas highlighted, the teacher leads the students to number the paragraphs and boxes on the affected pages of the textbook using (coloured) pencils for easy referencing.

Please note;

(a) This paragraph numbering is done only on the first day of the lesson on any new topic,

(b) Page=p, Pages=pp, Paragraph=pgf, Paragraphs=pgfs, Reference=ref.

Step 1V: Teacher gives small exercise to assess their level of understanding to use the numbered paragraphs by instructing the different students groups to:

Open the textbook (Ababio) to ref. p. 269 and do the following small exercise.

Group 1, mention the sub-topic on pgf 1; Group 2, heading on pgf. 5; Group 3, sub heading on pgf 8; etc (Answer:1. Natural and Treated Water, 2.Treated Water, 3.Water supply to a township etc.) Corrections are made for those who did not get it right.

For more trial exercise, teacher gives the students fifteen minutes to read through paragraphs 1-3 the same p. 269, for further discussions on the topic for the day.

Step V:

Teacher guides the students to mention different sources of water and their characteristics;

Rain water:- It is the purest form of natural water because it is formed as a result of the condensation of water vapour in the atmosphere i.e. it is the natural form of distilled water. However, it is not clean enough for drinking due to the medium through which it is collected.

Sea or Ocean- salty and dirty because it contains a lot of dissolved air and mineral salt, bacteria and organic remains. It is not good for drinking or cooking.

1. River water- Like sea water, it is impure because of dissolved air, mineral salts and organic matter. Some shallow rivers collect so much debris from the land and empty them into the ocean or sea especially during and after rainfall. It has to be specially purified before it can be used for drinking and other domestic uses.
2. Spring- Contains a considerable amount of mineral salt, but very little suspended impurities such as dust and bacteria. It is a good source of water, comes from rocks; cool, clean for drinking and domestic use.

3. Well –It contains a lot of clay and other mineral salts. To be used for drinking or cooking, it must be sunk away from underground pollutants like pit latrines, oil-well etc. It is safer to boil the water before drinking.
4. Borehole- It is a deeper form of well. It is less polluted than the surface well. Reasonably clean and adequate for domestic use, but if dug in an area with high deposit of calcium or Magnesium trioxocarbonate (IV) e.t.c., it will pose a different type of problem as we have in the above case study.
5. Lake-water- It is not clean because it is stagnant and contains a lot of decayed organic matter and bacteria.

Step V1:

Teacher guides the students to suggest ways of making impure or polluted water clean for domestic use, by referring to the following pages, paragraphs and questions: (Ref. pp.269-270, pgfs.8-10)

a) When is water said to be polluted?

b.) Mention different ways to make polluted or impure water clean for human use.

c.) Suggest what you will do in order to constantly have clean water if the only source of water in your surrounding is:

1. River water.
2. Sea or Ocean water.
3. Spring water.
4. Rain water

Step VII:

Teacher guides the student in the discussion on polluted water and purification methods.

I. Water is said to be polluted when it contains impurities or pollutants like decayed organic matter, sediments, bacteria and other germs that are injurious to health. Samples of impure and pure water, alum, water filter candle are passed round the class for students to see and relate them to the discussion.

II. To make this water good and safe enough for domestic use, it has to be purified through the following methods; sedimentation, coagulation, filtration, disinfection, boiling, etc.; each of these methods, will be explained by the groups during the general group discussions using any of the instructional aides where applicable.

Step VIII.

Conclusion: Teacher concludes the lesson by;

a) Giving reading assignment and the assessment questions to prepare for the next lesson: Read 'Ababio' from pgf.5; p 269; heading-Treated Water, to pgf 30; p. 272; heading-Disadvantages of Hard water.

b) Asking the students to supply answers to the following questions and exercises as they read on.

1) If you use water from deep well or borehole to wash and lather did not readily form with soap, what kind of water is that?
2) Mention the three salts on p.270, pgf 11, which of these salts can be found in that kind of water?
3) What is scum?
4) Write the chemical formular of gypsum
5) What happens to $Ca(HCO_3)_2$ when the water is heated?
6) Which ion needs to be removed before the water can form lather easily?
7) Read pgf 17, p.271, and copy out the last word there.
8) On Experiment 16.1 box 1, p. 271, which processes are you instructed to repeat on pgf 3(box 1)?
9) In one sentence, explain what stalagmites and stalactites mean
10) Mention three chemicals that can be used to remove permanent hardness in water.
11) Copy out clearly as it is on p. 272, the equation of reaction between caustic soda and Magnisuim ion in the removal of permanent hardness of water.
12) Soduim zeolite occurs in nature as--------?
13) Is there any economic importance found in hard water?
14) Mention three of each.

APPENDIX V11B

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on PB &TwA Learning Approach (TMIPBTwALA)

TEACHER'S MANUAL:

METHOD: Problem-Based and Textbook-with-Assessment (PB & TwA) learning approach;

LESSON 2

SUB-TOPIC: Hardness in Water

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

- Define hardness in water and mention the two types.
- Mention salts that cause hardness in water and explain how it happens.
- Explain how hardness in water can be removed.
- Explain the effects of hard water in life.

INSTRUCTIONAL AIDS:

- Sample of hard water
- Washing soap
- Sample of calcium hydroxide
- Sample of sodium trioxocarbonate (IV)
- Sample of Permutit or Zeolite
- Furred kettle or pot or boiling ring

Step1. Introduction:

The borehole and other sources of hard water, require a different method of purification, which is mainly removal of the hardness in water.[Ref. text; Ababio;p. 270, pgf 11.

Step II: Teacher refers the students to the reading assignment given to them from the previous lesson and asks them to exchange their jotters for subsequent scoring in their groups as the lesson goes on. The reading assignment was based on hardness of water, causes, removal methods and economic importance to life. Through deductive questioning, occasional reference to the textbook, answering the assessment questions and students discussion of some sub-headings, teacher delivers his lesson for the day with active participation of the students from their groups, especially as they would be scoring the assessment questions along.

Step III. Hardness of water: Teacher assigns the following headings to different groups for class presentation. The groups will also demonstrate practically with the different types of hard water and their removal.

1. Origin of Hard Water
2. Types of Hard Water
   i. Temporary hardness
   ii. Causes and removal methods
3. Removal of temporary hardness
4. Effect of temporary hard water.

Step IV. Teacher occasionally refers the students back to the assessment questions to score the areas covered so far.

Step V. Teacher continues the lesson as the class discusses and practically demonstrates, as the case may be;

5. Permanent Hardness
   i. Causes and
   ii. Removal methods
6. Economic importance of hard water discussed as advantages and disadvantages of hard water to life.

Step V1. Conclusion: Teacher directs students back to score the last segment of the assessment questions, collects and records the marks, then summarizes the day's lesson which forms the students' note.

STUDENTS' NOTE:

I. Hard water is the water which does not form lather readily with soap.

II. It is water which contains a number of dissolved salts. Ordinary soap is usually sodium octadecanoate which is a soluble salt.

III. When soap is added to hard water, the dissolved salt in the water will immediately react with the soap molecules to form an insoluble substance called scum.

IV. Hard water is caused by any of the following soluble salts:-Gypsum-Calcium tetraoxosulphate (V1), ($CaSO_4.2H_2O$); Magnesium tetraoxosulphate (VI) ($MgSO_4$); Calcium hydrogentrioxocabonate(IV) [$Ca(HCO_3)_2$] and Limestone ($CaCO_3$). It is good to note that gypsum is sparingly soluble in water but limestone is not, only if it contains carbon (vi) oxide (CO_2).

Demonstration of the action of hard water and soft water on soap:

To demonstrate the action of hard water and soft water on soap the following items can be used; dirty napkin or handkerchief, washing soap, some quantity of hard and soft water in basins on a table.

Observation: They observe that it took a longer time for lather to form when washing with hard water than with the soft water.

Explanation: To explain the chemistry of what happened up till when lather began to form in both cases, it goes thus;

Ordinary soap is sodium octadecanoate. When this is added to hard water, the dissolved salt of Calcium or Magnesium tetraoxosulphate (VI) in the water will quickly react with the soap molecules and form insoluble Calcium or Magnesium salts. This is the unpleasant scum which sticks to the clothes and is difficult to rinse away. So much soap is required to precipitate and remove these ions before the actual washing begins. For the soft water, there is no dissolved salt, so the octadecanoate reacts with the water straight away to form lather which cleans the dirt.

Removal of Hardness in Water:

There are two types of hard water; Temporary and Permanent hard water. Since their chemical formation is different, their removal methods are also different.

Temporary hardness; causes and removal

Temporary hardness is caused by the presence of dissolved calcium hydrogentrioxocarbonate (IV), $Ca(HCO_3)_2$. This can easily be removed by boiling because $Ca(HCO_3)_2$ is easily decomposed on heating. The calcium trioxocarbonate(lV)

,Ca(CO_3) formed is insoluble and this brings the calcium ion out of the solution as a precipitate. Now, the soap that is added to the water will be available for lather to form.

$Ca(HCO_3)_2(aq) \xrightarrow{boil} CaCO_3(s) + H_2O(l) + CO_2(g)$

Soluble insoluble

Removal using Slaked lime

Temporary hardness can also be removed using slaked lime $Ca(OH)_2$.

$Ca(HCO_3)_2(aq) + Ca(OH)_2(s) \rightarrow 2CaCO_3(s) + 2H_2O(l)$

soluble slightly soluble insoluble

The soluble calcium hydrogentrioxocarbonate(lV) is precipitated as the insoluble calcium trioxocabonate(lV), thus removing out of the solution the calcium ions responsible for the hardness.

Permanent hardness; causes and removal

Causes:

This is a more serious type of hardness of water which can only be removed by using chemicals. It is caused by the presence of calcium and magnesium ions in the form of soluble tetraoxosulphate(VI) and chlorides.

Removal: The major principle is precipitating the calcium and magnesium ions from the solution. The chemical that can do it are soluble sodium compounds which will form insoluble precipitates with calcium and magnesium ions. Examples of these removal agents are caustic soda, washing soda and permutit or zeolite.

The reaction (i): Sodium trioxocarbonate(IV)(washing soda) removes these ions as insoluble calcium and magnesium trioxocarbonate (IV) respectively.

$Na_2CO_3(aq) + CaSO4(aq) \rightarrow CaCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

$Na_2CO_3(aq) + MgSO_4(aq) \rightarrow MgCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

Reaction (ii): Removal of hard water using caustic soda (sodium hydroxide) and show the equations of reaction.

Caustic soda removes the calcium and magnesium ions from solution as insoluble hydroxides respectively. (equations of reaction).

Reaction (iii): Permutit or Zeolite,is an ion-exchange resin used industrially and in the home for softening water. It appears naturally as sodium aluminum trioxo silicate (lV)(commonly called sodium zeolite).This can also be prepared artificially. As the hard water is passed through the resin, the sodium ions will go into the solution while the unwanted Ca and Mg ions go into the complex salt. (show the reaction)

(F) Negative and positive effects of hard water in our daily life?

i. Hard water tastes better than soft water because of the dissolved minerals in it.

ii. It helps to build strong teeth and bones because of the calcium salt in it.

iii. It helps snails and crabs build their shells, also because of the calcium it contains.

iv. Hard water does not dissolve lead, so it can be supplied through lead pipes unlike soft water which does.

Disadvantages of hard water:

i. Hard water causes wastage of soap.

ii. It causes furring of kettles, pots and boilers.

iii. Calcium and Magnesium decarnoate (insoluble scum) makes white fibers look dull.

iv. Hard water cannot be used in dyeing and tanning.

Step X. Teacher takes the students to "Ababio", pp.186-193, topic; Electrolysis, which is a new topic, and guides them to number the pages and paragraphs before giving them another set of reading assignment to prepare them for next lesson.

READING ASSIGNMENT: TOPIC: ELECTROLYSIS.

The headings to cover under this topic are;

1. Introductory lesson on electrolysis including definition of basic terms used in the process

2. Some examples of electrolysis e.g.

Electrolysis of Copper (II) tetraoxosulphate (VI) solution using different anodes.

3. Uses of electrolysis e.g.

i. Extraction and purification of metals and

ii. Electroplating

Textbook references are; a). Electrolysis-definition of terms; p.186,pgfs. 1-7, including box 1-:fig.11.18-: Simple electrolytic cell;

b). Some examples of electrolysis;p.191, pgfs 4-10,box 2, 11.24- Electrolysis of Acidified water; p.192,pgfs 11-15, Electrolysis of Copper(II)tetraoxosulphate(V1) solution (using carbon or platinum anode, box 3, 11.25); p.193, pgfs 16-18, box 4, 11.26, Electrolysis of copper(II)tetraoxosulphate (V1) using copper anode.

APPENDIX VIIC

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on PB &TwA Learning Approach (TMIPBTwALA)

TEACHER'S MANUAL
LESSON 3

METHOD: Problem-base and Textbook-with-Assessment (PB & TwA) learning approach.

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electrolysis of copper (II) tetraoxosulphate (VI) using copper anode.

BEHAVIOURAL OBJECTIVES:

At the end of the lesson, students should be able to:

- Define electrolysis, cathode, anode, cathodic and anodic reactions etc
- State the anodic and cathodic equations during the electrolysis of copper.
- Identify the ions in solution during the electrolysis of copper(II) tetraoxosulphate(VI).
- Explain the electrolysis of copper(II) tetraoxosulphate(V1) solution using copper anode.
- Draw and explain an electrolytic cell showing the above process.
- Explain the effect of electrolysis on any other salt.
- Give examples of where electrolysis can be applied in everyday life.

Procedure:

Step 1:

Students maintain their groups. Teacher takes off with questions orally, students' responses are counted as group representatives and points are recorded by the teacher for them as such. At the end of the lesson, the best group is recognized and praised accordingly.

Introduction

Teacher briefly goes through their previous lessons on metals as good conductor of electricity and electron producers to link it to electrolysis. In addition, he particularly picks out this statement, thus; in electrochemical cells, electricity is generated by a chemical change. The reverse is also possible, which means electric current can be used to bring about a chemical change. What reaction here is a chemical change? (Loss and gain of electrons by metals and non-metals)

Step II: Teacher gives the students a ten minutes exercise to do in their jotters in other to ascertain those who actually did the reading assignment:

1. From which paragraph on p.186 was the underlined passage lifted?

2. Define the following terms; electrolysis, electrodes, electrolytes, cathode, anode and electrolytic cell.

Step III: a). Teacher guides the students to define the above listed terms as they exchange their jotters to score. Electrolysis is the chemical decomposition of compound which takes place when an electric current passes through either a solution or molten form of the compound (definition of the other terms are given and scored also).

b). He went further to explain that in electrolytic reactions, there is always a half cathodic and a half anodic reaction. He asks the students to explain what cathodic and anodic reactions mean.

Answer: (Students made contributions and the teacher explains further)Cathodic and Anodic reactions are reactions that occur at the cathode and anode respectively. Example, during the electrolysis of copper (ll) tetraoxosulphate(V1) solution using copper anode, the ions in solution are as follows;

	$CuSO_4$	H_2O
Cations	$Cu^{2+}(aq)$	$H^+(aq)$
Anions	SO_4^{2-}	OH^-

Step IV:

c). Teacher explains what happens at negative electrode and asks the students to explain the reactions on the positive electrode as it was in pgr 11, p.192.

At the cathode (negative electrode), Cu^{2+} ion is preferentially discharged to H^+. The cathode reaction by implication is; $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$

At the anode (positive electrode), OH^- is preferentially discharged to SO_4^{2-} ion,

The anode reaction by implication is; $OH^- \rightarrow OH + e^-$

d). Teacher summarizes the reactions thus;

Cathodic half reaction: $2Cu^{2+} + 4e^- \rightarrow 2Cu$

Anodic half reaction: $40H \rightarrow 2H_2O + O_2 + 4e^-$

Overall reaction: $2Cu^{2+} + 4OH^- \rightarrow 2Cu + O_2 + 2H_2$

Step V:

e). Teacher leads the students to discuss how pure copper can be produced using the process of electrolysis and the accompanied half-cell equation of the reaction.

Copper will be used as anode electrode during the electrolysis of copper (II) tetraoxosulphate (V1) solution. The anodic half equation will then be:

$$Cu(s) \xrightarrow{-2e} Cu^{2+} \xrightarrow{+2e} Cu(s)$$

Step V1: Summary and Evaluation

Teacher uses the simple electrolytic cell diagram to explain further the above reaction and asked the following questions as oral quiz as he concludes the day's lesson, scoring and recording the points for the group representatives.

- What sign does anode have?
- Through which electrode do electrons leave the cell?
- Mention the ions in the electrolyte?
- Mention the anodic half equations when copper, carbon and platinum anodes are used in different electrolytic reactions.
- Which of the above reactions will produce pure copper that will not lose its luster?

- Briefly explain how the impure copper at the anode becomes pure copper at the cathode.

Diagram:

Conclusion:

Teacher gives reading assignment and assessment questions to cover the sub-topic for the next lesson and asks group leaders to coordinate the members to prepare properly for class quiz during the lesson.

i. Name the second most abundant metal on earth after alluminium, pgfs,30-41, P.444-446.(Iron).

ii. In what condition does it appear naturally? Ore

iii. What process does it undergo to bring it to a useable state? Process of extraction

iv. Mention the kinds of iron produced by this method in their order of increasing purity. Pig iron→Cast iron→Wrought iron→Steel (steel is an alloy of iron and carbon)

v. Which of these is commonly used in the production of cutleries? Wrought iron

vi. Teacher states that this is the kind of iron that most manufacturing companies use in the production of certain products like cutleries and it is bound to rust.

vii. What is the possible remedy to this? The process of electroplating

Study carefully;

(a) Uses of electrolysis

(b) Extraction and purification of metals and

(c) Electroplating.

APPENDIX V11D:

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on PB &TwA Learning Approach (TMIPBTwALA)

TEACHER'S MANUAL
LESSON 4

METHOD: Problem-Based learning and Textbook-with-Assessment learning (PB &TwA) approach.

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electroplating or Galvanizing steel.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- List at least three uses of electrolysis
- Mention different types of iron
- Define correctly the term Electroplating
- Describe briefly how silver can be electroplated on iron
- Give two reasons why electroplating is necessary
- Mention two other metals that could be used instead of silver and why.

Procedure:

Step 1:

Teacher calls up the groups in turns and asks them questions based on the take-home assessment questions and exercises given during the previous lesson. Examples;

Mention the uses of electrolysis, of all these uses, which one is most adequate for rust prevention? Electroplating

Step II: Teacher guides the students to define electroplating; as the electrical coating of one metal with another metal to secure improved appearance and greater resistance to corrosion (or durability). He asks more guiding questions as the lesson is developed and constantly referring them to the assessment questions.

Step III: Teacher guides the students into the full lesson.

Armed with the knowledge of electrolysis from last lesson, students are asked to discuss the procedure to carry out electroplating on iron using any of the adequate choice metals.

Procedure: Students make attempts

- ❖ The iron is first cleaned.
- ❖ Since it is a good conductor of electricity, it will be made the cathode in an electrolytic cell.
- ❖ The anode will be the pure copper, silver, gold, nickel or chromium to be deposited on the iron.
- ❖ The electrolyte will be the solution of the soluble salt of any of these metals of choice.

Step 1V: Teacher summarizes the presentation with a diagram example of silver plating of a table knife made of iron.

- ❖ The cathode is the table knife.
- ❖ The anode is a pure silver rod.
- ❖ The electrolyte is a solution of silver trioxonitrate (V)

Process; when current is passed through the cell, the silver rod dissolves at the anode and the ions produced migrate through the solution to the cathode, where they are deposited as a layer of silver on the knife.

Ionic Equation; Teacher asks the students to write the ionic equation of the reaction in their jotter. He goes round to score those who got it right and give follow up explanation to others.

At anode	In solution	At cathode
$Ag_{(s)}$ e-⟶	Ag $_{(aq)}$	e-⟶ $Ag_{(s)}$

Step V: Diagram of electrolytic cell: Ababio, p.186, fig.11.18.

Step VI: Evaluation;

Teacher answers any question from the students or offers further explanations where necessary.

Students copy the summary note and draw the diagrams.

Step VII: Teacher gives reading assignment and assessment questions to prepare for next lesson on the topic International Union Pure and Applied Chemistry (IUPAC) nomenclature by referring them to book one of New Approach Practical chemistry and Workbook (Eketunde) pp.60-65, as follows:

1. What is the oxidation number of Chlorine, Oxygen and Calcium in each of these compounds; CaH_2, H_2O_2 and NaCl.
2. Give the definition of acid, base and salt
3. What is the full meaning of this Acronym IUPAC?
4. Should all compounds made up of two elements be called binary compounds?
5. Support your answer with at least two examples.
6. State the first three rules in the naming of binary compounds.
7. Show the end product of these elements: Bromine, Chlorine, Hydride, Oxygen; when –ide is added to transform them.
8. What are binary compounds?
9. Give 3 examples.
10. Which category of compounds is described as Tertiary compounds?
11. Give 3 examples.
12. State the third rule in the naming of tertiary compounds.
13. Describe the position of oxidation number of an element in the naming of tertiary inorganic compounds. Give 2 examples.

APPENDIX V11E:

INSTITUTE OF EDUCATION

UNIVERSITY OF IBADAN

IBADAN, NIGERIA

Treatment Manual of Instruction on PB &TwA Learning Approach (TMIPBTwALA)

TEACHER'S MANUAL
LESSON 5

METHOD: Problem-Based learning (PB) and Textbook-with-Assessment learning (TwA) approach.

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: IUPAC nomenclature.

SUB-TOPIC: IUPAC Nomenclature under Acids and Bases.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- Identify and define acids and bases with examples
- State the rules for naming inorganic compounds and
- Give the IUPAC names of the compounds (acids and bases) correctly.

PROCEDURE:

Step 1:

Teacher states the problem on ground this way: The Chief Examiner's report on Students' Performance in Chemistry in WAEC MAY/JUNE 2006-2007 examination stated consistently that students had no firm (clear) understanding of the International Union of Pure and Applied Chemistry (IUPAC) nomenclature of compounds. How would this topic be taught to achieve an easier and faster understanding by the students to improve their performance?

Step II;

Teacher continues with the PBL and TAL strategy by encouraging the students to maintain their groups then and leads them to number the pages and paragraphs of the appropriate sections of the textbook. He introduces the lesson for the day as IUPAC Nomenclature of compounds and writes it on the board. He leads the students to recap the previous lesson on how to derive the oxidation number of elements in a compound using the following examples;

(a) $H\underline{N}O_3$ (b)$H\underline{N}O_2$ (c) $K_2\underline{Cr}_2O_7$ (d) $K\underline{Cl}O_3$

Determine the oxidation number of the underlined elements in each of these compounds (Ref. Eketunde, p.60, pgfs 1-4……)

Teacher reminds the students that one of the uses of oxidation numbers is the naming of compounds using the new IUPAC system.

Step III:

Teacher calls the attention of the students to the following remarks and Tips:

-this naming of compounds will be done under acids and bases for easier understanding.

-when you are given any compound to name, the first thing to do is to quickly find the oxidation number of the metal and/or non-metal in it, especially if any of the elements has variable oxidation numbers.

-the second is to follow the rules guiding the naming of that category of compounds step wise with optimum concentration.

-the third is to practice the naming several times, starting with the simpler compounds and gradually get to the more complex ones.

-if you have difficulty naming any compound seek a prompt assistance of your group members who understand it to put you through, using the textbook references and following the rules stepwise.

Step 1V:

Acids: Teacher asks the students; what is an acid? Students make attempts.

Definition; Acids are substances which when dissolve in water produces H^+ ion as the only positive ion in solution. Of the two kinds of acids; Inorganic and Organic acids, the focus will be on inorganic acids. What is a base? A base is an oxide or hydroxide of a metal, e.g. CaO, $Zn(OH)_2$ and NaOH. Bases are named as binary compounds. Teacher explains further that the rules for their naming are also the same as with acids but bases end in oxide or hydroxide.

(a) Binary compounds; Teacher asks the students to define what binary compounds are: They are compounds that contain only two elements; a few acids fall into this group. Teacher makes the different groups state in turns, the rules for naming binary compounds from the textbook references given, thus;

Rule 1: The first element, which may be metal or non-metal but the less electronegative (i.e. the more electropositive) element is named first with no change in the name; Eketunde, p.61,pgf 6

Rule 2: If the first element has variable oxidation numbers e.g. Cu=1 & 2, Fe=2 & 3, N=1-5 etc., the oxidation number of the element is written in Roman figure in brackets after the name of that first element e.g. Iron (II), Cu (1), Sulphur(1V); Eketunde, p.61, pgf 7.

Rule 3: Teacher instructs all students to state rule 3 out loud from p.62, pgf 8 together {The second element which is usually non-metal is named by replacing the last 2 or 3 letters of their name by letters –ide. These are the more electronegative elements. E.g. Chlor(ine)=Chlor(ide), Sulph(ur)=Sulph(ide), Oxygen=(oxide). HCl named hydrogen chloride; CaCl, (calcium chloride), NaBr (sodium bromide), $FeCl_3$ [Iron(III)Chloride]etc. Teacher refers them to p.61,pgfs 6-8 for more examples and allows them more time to practice

Examples	IUPAC Name
Fe_2O_3	Iron (III) oxide
NaOH	Sodium hydroxide
Zn $(OH)_2$	Zinc hydroxide

However, he cautions that the systematic ending is not applicable to some binary compounds such as; water (H_2O), ammonia (NH_3), and phosphine (PH_3).

Step V: Another group of elements that attract attention are called radicals. They are treated as single elements while naming their compounds; e.g. ammonium ($NH4^+$), hydroxide (OH^-) and cyanide (CN^-) even though they are made up of two elements. Teacher treats some examples and then asks the students from their groups to name the following; $Ca(OH)_2$, $Mg(OH)_2$, NH_4Cl, Cu_2O etc. Teacher refers students to the assessment questions and leads them to score up to the areas covered so far.

Step VI:

(b) Tertiary Compounds; these are compounds containing three elements e.g. $CaCO_3$.Teacher asks a student group representative to identify the three elements in this compound: Referring the students to pp.62-63, pgfs 10-14, he guides them through the naming of tertiary inorganic compounds.

Rules in naming tertiary inorganic compounds:

Rule 1:

The first element which is usually a metal is named first and if it has variable oxidation numbers, it will be written in Roman figure in bracket after the name of the element e.g. Iron(II);Cu(I)etc.

Rule 2: The oxygen atom in the compound is immediately named after the name of the first element as –oxo- and the number of the oxygen atom is indicated as di for 2; tri for 3; tetra for 4 before the name oxo e.g. Potassium tetraoxo, Copper(II) trioxo, Calcium dioxo.

Rule 3: The central element in the compound which could be a metal or non-metal e.g. Sulphur,Manganese, Chlorine etc. is named last by replacing the last 2 or 3 letters of the central element name with –ate e.g. Potasium-tetraoxo-sulphate(K_2SO_4) etc.{more examples}

Rule 4: The oxidation number of the central element is written in Roman figure in brackets after its name e.g. Copper(II) tetraoxosulphate(V1)[$CuSO_4$],more examples are given for further practices in their groups.

Step VII:

Some other common examples of tertiary inorganic compounds are –oxo-acids i.e. acids which contain oxygen atoms in their molecules. The procedure for the naming is done as follows by the students from the reading assignment they did;

Rules:

1. Oxygen is named first as –oxo- with the number of atoms indicated by the Greek prefix di-oxo-(2), tri-oxo-(3) and tetra-oxo-(4).

2. The central atom which may be a metal or non-metal is then named with the ending –ate.

3. Its oxidation number designated by Roman numeral in bracket is named next.

4. The word acid is finally added to the name so formed. E.g. H_2SO_4 is an –oxo- acid of a non-metal (sulphur). It is named; tetra-oxo-sulphate(vi) acid because sulphur has an oxidation number of +6.

Teacher allows questions from students and supplies explanations. He then lists more acids to be named and allows the students to try them out in their groups and then to the general class until majority of the students are able to name the compounds; $HNO_{3,}$ $H_2SO_{3,}$ $H_3PO_{4,}$ $HClO_3$, $HClO_3$, HClO and $H_2CO_{3.}$

Teacher gives an example of –oxo- acid metal as $H_2Cr_2O_7$ and asks a student to try the naming.

Step VII: Acid radicals (oxoanions or Poly atomic ions)

Teacher points out that the rules for naming acids are the same as in naming oxoanions; (pp.65,pgfs 20-23) , the only difference is that acid radicals are formed by the partial or complete removal of hydrogen atoms from acids. Their names therefore are derived from the names of the corresponding acids by replacing the ending 'acid' by 'ion'. Examples; NO_3^- named tioxonitrate(v) ion, from trioxonitrate(v) acid. More examples for the students to practice and consolidate on are;

(a) SO_4^{2-} tetraoxosulphate(V1) ion

(b) CO_3^{2-} trioxocarbonate(1V) ion

(c) HCO_3^- hydrogentrioxocarbonate(1V) ion

(d) HSO_4^- hydrogentetraoxosulphate(V1) ion

EVALUATION

Teacher entertains questions from students and gives them more exercises to practice with in their groups to ensure that everybody is carried along.

Using the IUPAC system of nomenclature name the following

- Binary compounds; HCl, CaO, Na_2O
- -Oxo- acids; H_2SO_4, HNO_3, H_3PO_4, H_2CO_3
- Radicals; NO_2^-, MnO_4^-, $H_2PO_4^-$ and $S_2O_3^{2-}$.
- Bases; CaO, $Zn(OH)_2$, NaOH and Fe_2O_3

APPENDIX VIIIA

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLA)

TEACHER'S MANUAL:

LESSON 1

METHOD: Conventional Method of Teaching and Learning (for control group)

TOPIC: Water.

SUB-TOPIC: Sources of water and Purification

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

a) Mention different sources of water
b) List characteristics of these sources of water
c) Explain how these characteristics can affect life.
d) Identify the various causes of impurity.
e) Mention various ways of purifying different types of water.
f) Describe the implications of using unpurified water.
g) State the functions of each of the chemicals used in the process of purification and removal of hardness in water.
h) State the economic importance of hard water.

PREVIOUS KNOWLEDGE: The students have done water cycle and properties of water.

PROCEDURE:

Step 1:

Teacher quickly guides the students to recap their SS1 lesson on water cycle and properties of water and then introduces the topic for the day as; sources of water, characteristics and purification methods.

StepII: Teacher mentions that there are different sources of water and that determines their characteristics; he asks the students to mention the ones they know.

StepIII. Teacher presents the content of his lesson by dictating notes on sources of water and their characteristics and explains as he goes on.

1. Rain water:- It is the purest form of natural water because it is formed as a result of the condensation of water vapour in the atmosphere i.e. it is the natural form of distilled water. However, it is not clean enough for drinking due to the medium through which it is collected.

II. Sea or Ocean- salty and dirty because it contains a lot of dissolved air and mineral salt, bacteria and organic remains. It is not good for drinking or cooking.

III. River water- Like sea water, it is impure because of dissolved air, mineral salts and organic matter. Some shallow rivers collect so much debris from the land and empty them into the ocean or sea especially during and after rainfall. It has to be specially purified before it can be used for drinking and other domestic uses.

1V. Spring- Contains a considerable amount of mineral salt, but very little suspended impurities such as dust and bacteria. It is a good source of water, comes from rocks; cool, clean for drinking and domestic use.

V. Well –It contains a lot of clay and other mineral salts. To be used for drinking or cooking, it must be sunk away from underground pollutants like pit latrines, oil-well etc. It is safer to boil the water before drinking.

VI. Borehole- It is a deeper form of well. It is less polluted than the surface well. Reasonably clean and adequate for domestic use, but if dug in an area with high deposit of calcium or Magnesium trioxocarbonate (IV) e.t.c., it will pose a different type of problem as we have in the above case study.

VIl. Lake-water- It is not very clean because it is stagnant and contains a lot of decayed organic matter and bacteria.

Step V1:

Teacher treats ways of making impure or polluted water clean for domestic use, by asking and answering the following questions.

a) When is water said to be polluted?

b.) Mention different ways to make polluted or impure water clean for human use.

c.) Suggest what you will do in order to constantly have clean water if the only source of water in your surrounding is:

1. River water.
2. Sea or Ocean water.
3. Spring water.
4. Rain water or
5. Bore-hole water in an area with large deposit of limestone.

Water is said to be polluted when it contains impurities or pollutants like decayed organic matter, sediments, bacteria and other germs that are injurious to health.

To make this water good and safe enough for domestic use, it has to be purified through the following methods; sedimentation, coagulation, filtration, disinfection, boiling, etc.; each of these methods, except the borehole, will be explained by the teacher but for the borehole and other sources of hard water, the teacher says, different method is required which is mainly removal of the hardness and minor treatments. This will be the topic for next lesson.

Step VIII.

Conclusion: Teacher concludes the lesson by evaluating the students through the following questions:

1. Mention five sources of water.
2. What is polluted water?
3. Mention three ways to purify it.
4. List the four stages of purification in the water treatment plant.
5. Teacher corrects any obvious point of misconception.

APPENDIX VIIIB:

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLA)

TEACHER'S MANUAL:

METHOD: Conventional Method of Teaching and Learning (for control group).

LESSON 2

SUB-TOPIC: Hardness in Water

DURATION: Double Period

INSTRUCTIONAL OBJECTIVES:

At the end of the lesson, students should be able to:

a) Define hardness in water and mention the two types.
b) Mention salts that cause hardness in water.
c) Demonstrate the presence of hardness in a sample of water.
d) Explain how hardness in water can be removed.
e) Explain the economic importance of hard water in life.

INSTRUCTIONAL AIDS:

- Charts of different sources of water.
- Drawing of the water treatment plant.

PREVIOUS KNOWLEDGE:

- Students have done sources of water
- Purification and treatment of impure water.

Step1. Teacher reviews the previous lesson with the students and introduces the day's lesson by stating that the borehole and other sources of hard water require a different method of purification, which is mainly removal of the hardness in water.

StepII. Teacher presents the content of his lesson under the following sub-headings:

1. Tracing the origin of hard water as when water dissolved gypsum or limestone from the soil where the borehole was dug or over which stream or spring water flows. This makes it difficult for the water to form lather easily with soap.

2. Types of Hard Water: There are two types of hard water;

i. Temporary hardness is the characteristics of the hard water that can be removed by boiling. This hardness is caused by the presence of dissolved calcium hydrogentrioxocarbonate (1V) which decomposes by heat.

ii. Permanent hardness is a more serious situation where the hardness can only be removed with chemicals such as washing soda, caustic soda and permutit or zeolite. This type is caused by the presence of calcium and magnesium ions in the form of soluble tetraoxosulphate (V1) and chlorides.

3. Effect of temporary hard water e.g. wastage of washing soap.

4. Removal of temporary hardness.

5. Permanent Hardness

   i. Causes and

   ii. Removal methods

6. Economic importance of hard water discussed as advantages and disadvantages of hard water to life.

StepIII: Teacher talks and chalks through each of these contents and gives them note at the end of the lesson or leaves her note to the class captain to dictate to the class at any available free period.

Step 1V:

I. Hard water is the water which does not form lather readily with soap.

It is water which contains a number of dissolved salts. Ordinary soap is usually sodium octadecanoate which is a soluble salt. When soap is added to hard water, the dissolved salt in the water will immediately react with the soap molecules to form an insoluble substance called scum.

II. Hard water is caused by any of the following soluble salts:-Gypsum-Calcium tetraoxosulphate (V1), ($CaSO_4.2H_2O$); Magnesium tetraoxosulphate (VI) ($MgSO_4$); Calcium hydrogentrioxocabonate(IV) [$Ca(HCO_3)_2$] and Limestone ($CaCO_3$). It is good to note that gypsum is sparingly soluble in water but limestone is not, only if it contains carbon (1V) oxide (CO_2). Teacher talks more on hard water and the reaction with soap and formation of scum or lather.

Demonstration of the action of hard water and soft water on soap:

To demonstrate the action of hard water and soft water on soap the following items can be used; dirty napkin or handkerchief, washing soap, some quantity of hard and soft water in basins on a table. Teacher does the demonstration while students watch from their seats.

Observation: They observed that it took a longer time for lather to form when washing with hard water than with the soft water.

Explanation: To explain the chemistry of what happened up till when lather began to form in both cases, it goes thus;

Ordinary soap is sodium octadecanoate. When this is added to hard water, the dissolved salt of Calcium or Magnesium tetraoxosulphate (VI) in the water will quickly react with the soap molecules and form insoluble Calcium or Magnesium salts. This is the unpleasant scum which sticks to the clothes and is difficult to rinse away. So much soap is required to precipitate and remove these ions before the actual washing begins. For the soft water, there is no dissolved salt, so the octadecanoate reacts with the water straight away to form lather which cleans the dirt.

Step V: Removal of Hardness in Water:

There are two types of hard water; Temporary and Permanent hard water. Since their chemical formation is different, their removal methods are also different.

Temporary hardness; causes and removal

Temporary hardness is caused by the presence of dissolved calcium hydrogentrioxocarbonate (IV), $Ca(HCO_3)_2$. This can easily be removed by boiling because $Ca(HCO_3)_2$ is easily decomposed on heating. The calcium trioxocarbonate(lV) ,$Ca(CO_3)$ formed is insoluble and this brings the calcium ion out of the solution as a precipitate. Now, the soap that is added to the water will be available for lather to form.

$Ca(HCO_3)_2(aq) \xrightarrow{boil} CaCO_3(s) + H_2O(l) + CO_2(g)$

Soluble insoluble

Removal using Slaked lime

Temporary hardness can also be removed using slaked lime $Ca(OH)_2$.

$Ca(HCO_3)_2(aq) + Ca(OH)_2(s) \rightarrow 2CaCO_3(s) + 2H_2O(l)$

soluble slightly soluble insoluble

The soluble calcium hydrogentrioxocarbonate(lV) is precipitated as the insoluble calcium trioxocabonate(lV), thus removing out of the solution the calcium ions responsible for the hardness.

Permanent hardness; causes and removal

Causes:

Teacher goes on to explain that this is a more serious type of hardness of water which can only be removed using chemicals. It is caused by the presence of calcium and magnesium ions in the form of soluble tetraoxosulphate(VI) and chlorides.

Removal: The major principle is precipitating the calcium and magnesium ions from the solution. The chemical that can do it are soluble sodium compounds which will form insoluble precipitates with calcium and magnesium ions. Examples of these removal agents are caustic soda, washing soda and permutit or zeolite.

The reaction i: Sodium trioxocarbonate(IV)(washing soda) removes these ions as insoluble calcium and magnesium trioxocarbonate (IV) respectively.

$Na_2CO_3(aq) + CaSO4(aq) \rightarrow CaCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

$Na_2CO_3(aq) + MgSO_4(aq) \rightarrow MgCO_3(s) + Na_2SO_4(aq)$

Soluble insoluble

Reaction ii: Removal of hard water using caustic soda (sodium hydroxide) and show the equations of reaction.

Caustic soda removes the calcium and magnesium ions from solution as insoluble hydroxides respectively. (equations of reaction).

Reaction iii: Permutit or Zeolite, is an ion-exchange resin used industrially and in the home for softening water. It appears naturally as sodium aluminum trioxo silicate (lV)(commonly called sodium zeolite).This can also be prepared artificially. As the hard water is passed through the resin, the sodium ions will go into the solution while the unwanted Ca and Mg ions go into the complex salt. (show the reaction)

StepV1: Negative and positive effects of hard water in our daily life?

Teacher lists the advantages of hard water:

i. Hard water tastes better than soft water because of the dissolved minerals in it.

ii. It helps to build strong teeth and bones because of the calcium salt in it.

iii. It helps snails and crabs build their shells, also because of the calcium it contains.

iv. Hard water does not dissolve lead, so it can be supplied through lead pipes unlike soft water which does.

Disadvantages of hard water:

i. Hard water causes wastage of soap.

ii. It causes furring of kettles, pots and boilers.

iii. Calcium and Magnesium decarnoate (insoluble scum) makes white fibers look dull.

iv. Hard water cannot be used in dyeing and tanning.

Step VII: Conclusion.

Teacher concludes the lesson by giving the students take home assignment to read everything they have done in hardness of water for a class test next period.

APPENDIX VIIIC

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLA)

TEACHER'S MANUAL

LESSON III

METHOD: Conventional Method of Teaching and Learning (for control group).

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electrolysis of copper (II) tetraoxosulphate (V1) using copper anode.

BEHAVIOURAL OBJECTIVES:

At the end of the lesson, students should be able to:

- Define electrolysis
- State the anodic and cathodic equations during the electrolysis of copper.
- Identify the ions in solution during the electrolysis of copper(II) tetraoxosulphate(V1).
- Explain the electrolysis of copper(II) tetraoxosulphate(V1) solution using copper anode.
- Draw and explain an electrolytic cell showing the above process.

Procedure:

Step 1:

Teacher briefly revises previous lessons on the properties of metal as a good conductor of electricity through the movement of electrons from atom to atom.

Step II:

Teacher introduces the topic for the day; ELECTROLYSIS.

He asks the students; from your knowledge of integrated science chemistry define the following terms;

a) Electrolysis
b) Electrode
c) Electrolyte
d) Cathode
e) Anode
f) Electrolytic cell

Teacher dictates the definitions and makes the students read them back to her as she goes on.

- Electrolysis is the chemical decomposition of compound which takes place when an electric current passes through either a solution or molten form of the compound.
- Electrodes are conductors (poles of carbon or metal) through which electric current enters and leaves the electrolyte.
- Electrolyte is compound either in solution of molten form which conducts electric current and is decomposed at the electrodes in the process.
- Anode is the positive electrode by which the current enters the electrolyte or by which electron leave the electrolyte.
- Cathode is the negative electrode by which current leaves the electrolyte or by which the electrons enter the electrolyte.
- Electrolytic cell consists of a container of electrolyte with two electrodes connected to a suitable direct current supply.

Step III:

Development of the lesson continues as the teacher explains electrolytic reaction, cathodic and anodic half reactions, using half cell equations to explain the movement of electrons.

Electrolytic reaction is the reaction that takes place at the anode and the cathode and there is always a half cathodic and a half anodic reaction. Cathodic and Anodic reactions are reactions that occur at the cathode and anode respectively. Example, during the electrolysis of copper (II) tetraoxosulphate(VI) solution using copper anode, the ions in solution are as

$CuSO_4$	H_2O	
Cations	$Cu^{2+}(aq)$	$H^+(aq)$
Anions	SO_4^{2-}	OH^-

Step1V:

Teacher draws the diagram of the electrolytic cell and asks the students to do same in their notes. She briefly explains what happens during electrolysis: At the cathode (negative electrode), Cu^{2+} ion is preferentially discharged to H^+. The cathode reaction by implication is; $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$

At the anode (positive electrode), OH^- is preferentially discharged to SO_4^{2-} ion,

The anode reaction by implication is; $OH^- \rightarrow OH + e^-$.

Diagram:

Step V: Teacher summarizes the reactions thus;

Cathodic half reaction: $2Cu^{2+} + 4e^- \rightarrow 2Cu$

Anodic half reaction: $40H \rightarrow 2H_2O + O_2 + 4e^-$

Overall reaction: $2Cu^{2+} + 4OH^- \rightarrow 2Cu + O_2 + 2H_2$

Step V1: Teacher explains to the students how pure copper can be produced using the process of electrolysis and the accompanied half-cell equation of the reaction.

Copper will be used as anode electrode, electrolyte is copper (II) tetraoxosulphate (V1) solution. The anodic half equation will then be:

$$Cu(s) \xrightarrow{-2e} Cu^{2+} \xrightarrow{+2e} Cu(s)$$

EVALUATION: Teacher ends the lesson by asking the following questions as verbal quiz to the students.

- What sign does anode have?
- Through which electrode do electrons leave the cell?
- Mention the ions in the electrolyte?
- In your jotter, write the anodic half equations when copper, carbon and platinum anodes are used in different electrolytic reactions.
- Which of these reactions will produce pure copper that will not lose its luster?
- Briefly explain how the impure copper at the anode becomes pure copper at the cathode.

APPENDIX VIIID:

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Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLA)

TEACHER'S MANUAL:

METHOD: Conventional Method of Teaching and Learning (for control group).

LESSON 4:

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: Electrolysis.

SUB-TOPIC: Electroplating or Galvanizing steel.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- List at least three uses of electrolysis
- Mention different types of iron
- Define correctly the term Electroplating
- Describe briefly how silver can be electroplated on iron
- Give two reasons why electroplating is necessary
- Mention two other metals that could be used instead of silver.

Procedure:

Step 1;

Teacher introduces the day's lesson: ELECTROPLATING.

Teacher guides the students to mention the uses of electrolysis. Which of these uses will improve the quality of metals used to manufacture cutleries to prevent it from rusting or change of colour? Electroplating or Galvanizing.

Step II: Teacher defines electroplating as the electrical coating of one metal with another metal to secure improved appearance and greater resistance to corrosion. Armed with the knowledge of electrolysis from last lesson, teacher explains the process of electroplating. He briefly talks about metals e.g. iron, its nature and extraction process, types of iron and their levels of purity as well as their uses. [Pig iron→Cast iron→Wrought iron→Steel (steel is an alloy of iron and carbon)

Step III: Teacher explains that wrought iron is the type that some cutlery manufacturing industries use in their production and it rusts. So, one of the reliable solutions is the process of electroplating and he goes into the full lesson.

Procedure:

- ❖ The iron is first cleaned.
- ❖ Since it is a good conductor of electricity, it will be made the cathode in an electrolytic cell.
- ❖ The anode will be the pure copper, silver, gold, nickel or chromium to be deposited on the iron.
- ❖ The electrolyte will be the solution of the soluble salt of any of these metals of choice.

Step 1V: Teacher summarizes the presentation with a diagram example of silver plating of a table knife made of steel.

- ❖ The cathode is the table knife.
- ❖ The anode is a pure silver rod.
- ❖ The electrolyte is a solution of silver trioxonitrate (V)

Process; when current is passed through the cell, the silver rod dissolves at the anode and the ions produced migrate through the solution to the cathode, where they are deposited as a layer on the knife.

Ionic Equation;

At anode	In solution	At cathode
$Ag_{(s)}$ e-⟶	Ag $_{(aq)}$	e-⟶ $Ag_{(s)}$

Diagram of electrolytic cell to demonstrate electroplating

Evaluation; Teacher answers any question from the students or offers further explanations where necessary. Students copy the summary note and draw the diagrams.

APPENDIX VIIIE:

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Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLA)

TEACHER'S MANUAL

LESSON 5:

METHOD: Conventional Method of Teaching and Learning (for control group).

SUBJECT: Chemistry.

CLASS: SS2.

PERIOD: Double Period.

TOPIC: IUPAC nomenclature under Acids, Bases and Salts

SUB-TOPIC: IUPAC Nomenclature under Acids.

BEHAVIOURAL OBJECTIVES: At the end of the lesson students should be able to;

- State the rules for naming inorganic compounds
- Identify and define acids and give examples and
- Give the IUPAC names of the acids correctly.

PREVIOUS KNOWLEDGE: Students have been taught;

1. Oxidation numbers.
2. How to calculate the oxidation numbers of elements.
3. Uses of oxidation numbers of elements.

PROCEDURE:

Step 1:

Teacher introduces the lesson for the day as IUPAC Nomenclature in Acids and writes it on the board. He then leads the students to recap the previous lesson on how to derive the oxidation number of elements in a compound using the following examples;

(a) $H\underline{N}O_3$ (b)$H\underline{N}O_2$ (c) $K_2\underline{Cr}_2O_7$ (d) $K\underline{Cl}O_3$

Determine the oxidation number of the underlined elements in each of the compounds.

Teacher reminds the students also that one of the uses of oxidation numbers is the naming of compounds using the new International Union of Pure and Applied Chemistry (IUPAC) system. This naming will be done under acids, bases and salts.

Step II:

Acids:

Definition; Acids are substances which when dissolve in water produces H^+ as the only positive ion in solution. The two kinds of acids; Inorganic and organic acids, but our focus is on inorganic acids only.

Teacher goes on to state the rules for naming the acids.

(a) Binary compounds; these are compounds that contain only two elements; their names end in –ide. The less electronegative (i.e. the more electropositive) element is named first with no change in the name, while the more electronegative element is named last with its name modified to end with –ide, e. g. HCl named hydrogen chloride. Others are; CaCl, (calcium chloride), NaBr (sodium bromide). Teacher refers them to p.61,pgfs 6-8 for more examples of base and allows them more time to practice

Examples	IUPAC Name
Fe_2O_3	Iron (III) oxide
NaOH	Sodium hydroxide
Zn $(OH)_2$	Zinc hydroxide

However,this systematic ending is not applicable to some binary compounds such as; water (H_2O), ammonia (NH_3), and phosphine (PH_3). Also these radicals are treated as single elements while naming their compounds-ammonium ($NH4^+$), hydroxide (OH^-) and cyanide (CN^-). Teacher asks the students to name the following examples; $Ca(OH)_2$, $Mg(OH)_2$, NH_4Cl etc.

Step III:

(b) Tertiary and Quaternary Compounds; these are compounds containing more than two elements. They are –oxo-acids i.e. acids which contain oxygen atoms in their molecules. The procedure for naming them is as follows;

1. Oxygen is named first as –oxo- with the number of atoms indicated by the Greek prefix mono –(1), di-(2), tri-(3) and tetra-(4).

2. The central atom which may be a metal or non-metal is then named with the ending –ate and its oxidation number designated by Roman numeral in bracket.
3. The word acid is finally added to the name so formed. E.g. H_2SO_4 is an –oxo- acid of a non-metal (sulphur). It is named; tetra-oxo-sulphate(vi) acid because sulphur has an oxidation number of +6.

He lists more acids and names them while the students copy.

HNO_3, H_2SO_3, H_3PO_4, $HClO_3$, $HClO_3$, $HClO$ and H_2CO_3.

Teacher gives an example of –oxo- acid metal as $H_2Cr_2O_7$.

Step IV: Acid radicals (oxoanions)

Acid radicals are formed by the partial or complete removal of hydrogen atoms from acids. Their names are derived from the names of the corresponding acids by replacing the ending 'acid' by 'ion'. Examples; NO_3^- named tioxonitrate(V) ion, from trioxonitrate(V) acid. He lists more examples for students to copy;

(a)	SO_4^{2-}	tetraoxosulphate(V1) ion
(b)	CO_3^{2-}	trioxocarbonate(1V) ion
(c)	HCO_3^-	hydrogentrioxocarbonate(1V) ion

EVALUATION

Teacher gives the students more exercises to do.

Using the IUPAC system of nomenclature name the following

- Binary compounds; HCl, CaO, Na_2O
- -Oxo- acids; H_2SO_4, HNO_3, H_3PO_4, H_2CO_3
- Radicals; NO_2^-, MnO_4^-, $H_2PO_4^-$ and $S_2O_3^{2-}$
- Bases; CaO, $Zn(OH)_2$, NaOH and Fe_2O_3

APPENDIX 1X A

INSTITUTE OF EDUCATION
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CHEMISTRY PRACTICALS

Treatment Manual of Instruction on PB learning Approach for Practicals (TMIPBLAP)

TEACHER'S MANUAL

METHOD: Problem-Based (PB) learning approach

LESSON: 1

CLASS: SS2

SUBJECT: Chemistry Practicals

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES: At the end of the lessons, students should be able to:

1. Name all the apparatus necessary for the titration reaction involving acid and base.
2. Clamp burette onto the iron stand firmly without breaking it.
3. Pipette correctly required volume of acid into the conical flask.
4. Operate freely the control knob of the burette to let acid into the conical flask.
5. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
6. Observe all precautions associated with the titration exercise.
7. Fill the titre table correctly.

PROCEDURE:

Step 1: Teacher leads the students to reconstitute a new group of three each for practicals. He reaffirms the continuation of the Problem-based-learning approach but this time in practical chemistry and encourages them to maintain the same attitude of group co-operation, assisting one another to learn and brainstorm where necessary for the easiest way to solve problems. The problem focus here is based on the WAEC and NECO chief examiners' post-marking-reports such as; "inadequate and insufficient exposure of students to practical exercises, inability to link theoretical knowledge of apparatus with actual practical function and incorrect tabulation of titration values" are some of the weaknesses which need to be addressed.

Step II: Teacher guides the students to mention the safety measures to be observed in the laboratory during practicals e.g., no eating nor drinking in the lab., rinse burette with small quantity of acid, pipette with base and the other apparatus with distilled water before using them etc.

Step III: Teacher and the lab. assistants provide each student group complete sets of the apparatus required for the titration on their table e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle, labeled beakers containing acid and base required for the titration, etc.

NOTE: For this first titration involving students, acidulated distilled water, pH scale 6 and highly diluted base, pH scale 8, are going to be used to prevent the adverse effect of unavoidable sucking and splashing of the chemicals which are common with first-time users of pipette and burette.

Step 1V: Teacher having his own set of the apparatus too instructs the students to go along with him stepwise in the titration procedure as follows;

a. Fix the burette onto the clamp and stand, firmly but carefully after me.
b. Place the white tile at the flat base of the stand and keep one of the conical flasks there.
c. Using funnel, fill the burette with acid solution in the beaker to reach the zero mark at the upper part, watching the meniscus and adjust the volume to zero mark through the knob on the burette.
d. Teacher asks the students to mention the highest volume of the burette and the pipette they are using---(100cm^3-25cm^3 respectively)
e. Pick up your pipette and hold it upright like mine and identify the mark at the upper part.
f. Dip it into the beaker of base and suck the liquid carefully, watching as the liquid moves up the pipette until it slightly passes the mark, stop and quickly cover the pipette by placing your index finger on the mouth. Carefully adjust the level to the mark by gently lifting your finger. Teacher gives them time to practice.

g. Empty the content into the conical flask labeled A. Repeat the action for two other flasks.
h. Put two drops of the methyl orange indicator into each of the content of the flasks. Shake the flasks, note any colour change and keep aside.
i. Draw the titre table and record the initial volume of acid before titration commences which is usually zero on the second line as shown. Teacher draws the sample of titre table on the board.
j. Begin to titrate the base with the acid from the burette, gradually watching out for any colour change which will mark the end point or neutralization point.
k. Read the volume of acid used as shown on the burette and record on the first line on the table under Readings as Final. Teacher asks a student to explain why it should be arranged like that? More explanations are given for better understanding.
l. Repeat the process for the content of the other two conical flasks, by either refilling the burette to zero level or continue from where he stopped if the volume of acid left will be sufficient.
m. Record the volumes of acid used.
n. Finally calculate the average titre volume by adding two concordant values and divide by two.
o. Teacher explains further the technique of concordance value.

Step V: Teacher and the lab. attendants go round continuously to supervise what the students are doing and effect corrections where necessary.

Step V1: Teacher allows them more time to round up and cross-check their work. On satisfaction, he instructs the students to

- submit their practical notes,
- clean up their tables and the apparatus used,
- stand beside their table for inspection by the lab. attendant.

APPENDIX 1Xb

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on PB learning Approach for Practicals (TMIPBLAP)

TEACHER'S MANUAL

METHOD: Problem-Based (PB) learning approach

LESSON:2

CLASS: SS2

SUBJECT: Chemistry Practicals

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES:

At the end of the lessons, students should be able to:

1. Write a correct list of the apparatus required to carry out titration exercise successfully.
2. Operate freely the control knob of the burette to let acid into the conical flask.
3. Operate freely the pipette to let base into the conical flask.
4. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
5. Carry out the titration of any set of acid and base confidently with minimal supervision.
6. Observe promptly the end point or neutralization point of acid to base.
7. Work out and fill correctly on the table the average volumes of the acid used.
8. Observe all precautions associated with the titration exercise.

PROCEDURE

Step 1: Teacher instructs that

1. the students maintain their groups,
2. each student should tear a sheet of paper and write down all the apparatus she/he will use to carry out the titration exercise and submit through the group leader to the teacher.

3. the lab. attendants supply every student a set of the apparatus and the reagents but purposely omitting one important item.
4. the students cross check the apparatus on their table and identify any omissions.
5. the lab. attendants supply every student group the identified apparatus or reagents omitted which of course varies from group to group.

Step II: Teacher writes the titration instruction on the board, thus:

Burette readings (initial and final) must be recorded appropriately. Volume of pipette used must be recorded but no account of experimental procedure is required. All calculations must be done in your answer sheet.

The reagent A is 0.500 mol dm^{-3} solution of HCl acid. The reagent B is a solution of K0H containing 2.5g per $500cm^{3}$ solution.

Method; Put A into the burette and titrate it against 25.0 cm^{3} portion of B using methyl orange indicator. Repeat the titration to obtain consistent titres. Tabulate your readings and calculate the average volume of A used.

Step III: Teacher allows the students time to set the apparatus for the experiment.

NOTE: The students are now using the correct concentration of acid and base for this titration as they have moderately mastered the use of the apparatus.

Step 1V: As the students start working, the teacher quickly goes through the list of the apparatus they submitted and identifies those who did not get it right.

Step V: Teacher and the lab. attendants go round to supervise the students' activities and offer any necessary assistance and corrections, encouraging the group leaders to assist members of her group or call the attention of the teacher or the attendants.

Step V1: Teacher gives general corrections based on their observations from the students' activities and calls out the names of those who did not get the list of the apparatus needed for the titration exercise correctly, and tells them to take note of the omissions.

Step V11: Teacher instructs that the students should submit their practical note book, clean out their environment and the apparatus used and stand beside it for inspection.

CONCLUSION: Teacher announces that the next practical lesson will be the last and that will be the post-test examination, to mark the end of the program, so students should prepare properly and go through everything they have been taught.

APPENDIX 1XC

INSTITUTE OF EDUCATION
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Treatment Manual of Instruction on PB learning Approach for Practicals (TMIPBLAP)

TEACHER'S MANUAL

METHOD: Problem-Based (PB) learning approach

LESSON:3

CLASS: SS2

SUBJECT: Chemistry Practicals

PERIOD: Double period

OBJECTIVES: Post-test Administration.

PROCEDURE

Step 1:

The lab. attendants supply every student the apparatus or reagents required for the titration exercise

Step II: Teacher releases the Practical CHEMAT for the post-test.

Burette readings (initial and final) must be recorded appropriately. Volume of pipette used must be recorded but no account of experimental procedure is required. All calculations must be done in your answer sheet.

The reagent A is a solution of trioxonitrate (V) acid containing 2.15g in $500cm^{-3}$ solution of acid. The reagent B is a solution obtained by taking $25cm^3$ of a saturated solution of potassium trioxocarbonate (1V) in $500cm^3$distilled water.

Put A into the burette and titrate it against 25.0 cm^3 portion of B using methyl orange indicator. Repeat the titration to obtain consistent titres. Tabulate your readings and calculate the average volume of A used.

Step III: Teacher and the lab. attendants go round to ensure that the students' are supplied all the apparatus and the reagents required.

Step 1V: As the students start working, the manipulative skill test raters go to the group of five students they rated during the pre-test to observe and rate them for this post-test. At the end of the exercise, the students' practical exercise books are collected as well as the rating formats for each student.

CONCLUSION: Teacher scores and records the post-test.

APPENDIX XA

INSTITUTE OF EDUCATION
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IBADAN, NIGERIA

Treatment Manual of Instruction on TwA learning Approach for Practicals (TMITwALAP)

TEACHER'S MANUAL

METHOD: Textbook-with-Assessment (TwA) learning approach

LESSON: 1

CLASS: SS2

SUBJECT: Chemistry Practicals

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES: At the end of the lessons, students should be able to:

1. Name all the apparatus necessary for the titration reaction involving acid and base.
2. Clamp burette onto the iron stand firmly without breaking it.
3. Pipette correctly the required volume of acid into the conical flask.
4. Operate freely the control knob of the burette to let acid into the conical flask.
5. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
6. Observe all precautions associated with the titration exercise.
7. Fill the titre table correctly.

PROCEDURE:

Step 1: Teacher reaffirms the continuation of the Textbook-With-Assessment Learning (TAL) approach but this time in practical chemistry and encourages them to maintain the same attitude of making the textbooks their closest friend and companion in the study of chemistry. He then refers them to the textbook topic under Titration, p. 94 of the Modern-Day Chemistry Practical Text and Manual by Sanda, O.E. and p.8, New Approach, Practical Chemistry and Workbook, Book 2.by Eketunde,O. A.

Step II: Teacher guides the students to number the paragraphs, tables and figures on the affected pages in the recommended texts mentioned above. Referring them to Sanda p.96, pgf.19 and Eketunde, p.8, pgf 5, he instructs them to mention the safety measures and precautions during Acid-Base Titration Experiment in the laboratory during practicals, e.g. rinse clean burette with small quantity of acid, rinse pipette with base and the other apparatus with distilled water before using them etc.;

Step III: Teacher again refers the students to Sanda, p.95, fig.4 items a-g to observe and study their uses for about 5 minutes. The laboratory attendants now provide each student group complete sets of the apparatus required for the titration on their table e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle, labeled beakers containing acid and base, etc.

NOTE: For this first titration involving students, acidulated distilled water, pH scale 6 and highly diluted base, pH scale 8, are going to be used to prevent the adverse effect of unavoidable sucking and splashing of the chemicals which are common with first-time users of pipette and burette.

Step 1V: Teacher having his own set of the apparatus and textbook, instructs the students to open to p. 95 of Sanda, and go along with him stepwise in the titration procedure as follows;

a. Fix the burette onto the clamp and stand, firmly but carefully after me.
b. Place the white tile at the flat base of the stand and keep one of the conical flasks there.
c. Using funnel, fill the burette with acid solution in the beaker to reach the zero mark at the upper part, watching the meniscus and adjust the volume to zero mark through the knob on the burette.
d. Teacher asks the students to mention the highest volume of the burette and the pipette they are using---(50cm^3-25cm^3 respectively)
e. Pick up your pipette and hold it upright like mine and identify the mark at the upper part.
f. Dip it into the beaker of base and suck the liquid carefully, watching as the liquid moves up the pipette until it slightly passes the mark, stop and quickly cover the pipette by placing your index finger on the mouth I.e. the upper opening of the

pipette. Carefully adjust the level to the mark by gently lifting your finger. Teacher gives them time to practice.

g. Empty the content into the conical flask labeled A. Repeat the action for two other flasks.
h. Put two drops of the methyl orange indicator into each of the content of the flasks. Shake the flasks, note any colour change and keep aside.
i. Draw the titre table and record the initial volume of acid before titration commences which is usually zero on the second line as shown. Teacher draws the sample of titre table on the board.
j. Begin to titrate the base with the acid from the burette gradually, watching out for any colour change which will mark the end point or neutralization point.
k. Read the volume of acid used as shown on the burette and record on the first line on the table under Readings as Final. Teacher asks a student to explain why it should be arranged like that? More explanations are given for better understanding.
l. Repeat the process for the content of the other two conical flasks, by either refilling the burette to zero level or continue from where he stopped if the volume of acid left will be sufficient.
m. Record the volumes of acid used.
n. Finally calculate the average titre volume by adding two or three concordant values and divide by two or three respectively.

Teacher explains further the technique of identifying concordant values and allows the students to practice with more examples.

Step V: Teacher and the lab. attendants go round continuously to supervise what the students are doing and effect corrections where necessary.

Step V1: Teacher allows them more time to round up and cross-check their work. On satisfaction, he instructs the students to

- submit their practical notes,
- clean up their tables and the apparatus used,
- stand beside their table for inspection by the lab. attendant.

Step V11: Teacher releases the reading assignment for students to prepare for next practical class; Study with and read through pp. 94-96, pgfs 1-14 of Sanda, and pp.7-13, pgfs 1-14 of Eketunde and answer the assessment questions that follow.

1. Which aspect of chemistry practical is this called? titration or Volumetric analysis
2. Mention two major reagents needed for this experiment? Acid and Base
3. List 6 major apparatus that will be used for the experiment.
4. Write the functions of the following apparatus; white tile, funnel and burette knob.
5. Give the reason why you should not blow into the pipette
6. Justify the reason for rinsing the burette with acid and the pipette with base before using them.
7. Mention three common indicators used for titration exercise.
8. What is the function of the indicator in neutralization process?
9. Why should the process be performed two or three times over?
10. What is the range for determining the concordance value?
11. What assists you to avoid the error of parallax?

APPENDIX Xb

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on TwA learning Approach for Practicals (TMITwALAP)

TEACHER'S MANUAL

METHOD: Textbook-with-Assessment (TwA) learning approach

LESSON: 2

CLASS: SS2

SUBJECT: Chemistry Practical

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES: At the end of the lessons, students should be able to:

i. sign and collect complete apparatus they will require to carry out the titration exercise successfully.
ii. Confidently clamp burette onto the iron stand firmly without breaking it.
iii. Pipette correctly required volume of acid into the conical flask without mistakenly sucking in the acid.
iv. Operate freely the control knob of the burette to let acid into the conical flask.
v. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
vi. Observe promptly the end point or neutralization point of acid to base.
vii. Observe all precautions associated with the titration exercise.
viii. Fill the titre table correctly.

PROCEDURE:

Step I: Teacher refers the students to the study questions given during the last practical lesson.

Step II: Teacher instructs the students to exchange their practical notes where they answered the assessment questions and guides them to score themselves. He controls the students to supply answers to the questions and mark.

Step III: Teacher introduces the practical lesson for the day which is: Real Titration Practical Experiment. He then refers the students to Sanda, p.98, pgfs 19-21 and explains further what they are going to do. The laboratory attendants have provided each student a set of the apparatus required for the titration on their tables but deliberately skipping one important apparatus from each student e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle, labeled beakers containing acid and base, etc.

Step 1V: Teacher then announces that students cross check the set of apparatus provided for them to ensure they are complete and in good condition. By this the students refresh their knowledge of the list of the apparatus once more. The lab attendants complete the omissions and the students go on with the practical experiment given on p. 98 of Sanda, pgfs 20-21.

NOTE: The students are now using the correct concentration of acid and base for this titration as they have moderately mastered the use of the apparatus.

Step 1V: Teacher and the lab. attendants go round continuously to supervise what the students are doing and effect corrections where necessary.

Step V: Teacher explains further the technique of identifying concordant values and allows the students to go on.

Step V1: Teacher allows them more time to round up and cross-check their work. On satisfaction, he instructs the students to

- submit their practical notes,
- clean up their tables and the apparatus used,
- stand beside their table for inspection by the lab. attendant.

Step VII: Teacher releases the reading assignment and exercises for students to prepare for next practical class which is going to be the post-test examination.

Practice more using the table 4 on p.99 of Sanda and table 3 on p.17 of Eketunde:

i. the titre table format.

ii. Filling the table.

iii. Identifying the concordance values.

iv. Calculating the average titre.

v. Read the warnings on pgf.27,p.18 of Eketunde and take them to heart to guide your actions throughout titration exercises.

APPENDIX XC

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on TwA learning Approach for Practicals (TMITwALAP)

TEACHER'S MANUAL

METHOD: Textbook-with-Assessment (TwA) learning approach

LESSON: 3

CLASS: SS2

SUBJECT: Chemistry Practicals Post-test Administration

PERIOD: Double period

OBJECTIVES: To compare the performance of the students after the treatment with their performance before the treatment using the result of the pre-test taken earlier on.

PROCEDURE:

Step I: Teacher asks how many of the students did the reading assignment and are ready for the final test?

Step II: Teacher introduces the posttest examination by giving out the practical chemistry question papers to be distributed by the research assistants.

Step III: The laboratory attendants have provided each student a complete set of the apparatus required for the titration on their tables e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle/labeled beakers containing acid and base, etc.

Step 1V: Students start off the test.

Instructions: Burette readings (initial and final) must be recorded appropriately. Volume of pipette used must be recorded but no account of experimental procedure is required. All calculations must be done in your answer sheet.

The reagent A is a solution of trioxonitrate (V) acid containing 2.15g in $500cm^{-3}$ solution of acid. The reagent B is a solution obtained by taking $25cm^3$ of a saturated solution of potassium trioxocarbonate (1V) in $500cm^3$distilled water.

Put A into the burette and titrate it against 25.0 cm^3 portion of B using methyl orange indicator. Repeat the titration to obtain consistent titres. Tabulate your readings and calculate the average volume of A used.

Step V: The manipulative skill test raters go on to rate the five students they rated during the pre-test to observe and rate them for this post-test. At the end of the exercise, the students' practical exercise books are collected as well as the rating formats for each student.

CONCLUSION: Teacher scores and records the post-test.

APPENDIX X1A

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on PB and TwA learning Approach for Practicals (TMIPB&TwALAP)

TEACHER'S MANUAL

METHOD: Problem-based and Textbook-with-Assessment (PB and TwA) learning approach

LESSON: 1

CLASS: SS2

SUBJECT: Chemistry Practical

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES: At the end of the lessons, students should be able to:

1. Name all the apparatus necessary for the titration reaction involving acid and base.
2. Clamp burette onto the iron stand firmly without breaking it.
3. Pipette correctly the required volume of acid into the conical flask.
4. Operate freely the control knob of the burette to let acid into the conical flask.
5. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
6. Observe all precautions associated with the titration exercise.
7. Fill the titre table correctly.

Step 1: Teacher reaffirms the continuation of the Problem-based Learning (PBL) and Textbook-With-Assessment learning (TwA) approach but this time in practical chemistry and encourages them to maintain the same attitude of studying chemistry by using their textbooks and working in their groups with their colleagues. The problem focus here is based on the WAEC and NECO chief examiners' post-marking-reports such as; "inadequate and insufficient exposure of students to practical exercises, inability to link theoretical knowledge of apparatus with actual practical function and incorrect tabulation of titration values" are some of the weaknesses which need to be addressed. He then refers them to the textbook topic under Titration, p. 94 of the Modern-Day Chemistry Practical Text and Manual by Sanda, O.E. and p.8, New Approach, Practical Chemistry and Workbook, Book 2.by Eketunde,O. A.

Step II: Teacher guides the students to number the paragraphs, tables and figures on the affected pages in the recommended texts mentioned above. Referring them to Sanda p.96, pgf.19 and Eketunde, p.8, pgf 5, he instructs them to mention the safety measures and precautions during Acid-Base Titration Experiment in the laboratory during practical, e.g. rinse clean burette with small quantity of acid, rinse pipette with base and the other apparatus with distilled water before using them etc.;

Step III: Teacher again refers the students to Sanda, p.95, fig.4 items a-g to observe and study their uses for about 5 minutes in their groups. The laboratory attendants now provide each student group complete sets of the apparatus required for the titration on their table e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle, labeled beakers containing acid and base, etc.

NOTE: For this first titration involving students, acidulated distilled water, pH scale 6 and highly diluted base, pH scale 8, are going to be used to prevent the adverse effect of unavoidable sucking and splashing of the chemicals which are common with first-time users of pipette and burette.

Step 1V: Teacher having his own set of the apparatus and textbook, instructs the students to open to p. 95 of Sanda, and go along with him stepwise in the titration procedure as follows;

a. Fix the burette onto the clamp and stand, firmly but carefully after me.

b. Place the white tile at the flat base of the stand and keep one of the conical flasks there.

c. Using funnel, fill the burette with acid solution in the beaker to reach the zero mark at the upper part, watching the meniscus and adjust the volume to zero mark through the knob on the burette.

d. Teacher asks the students to mention the highest volume of the burette and the pipette they are using---($50cm^3$-$25cm^3$ respectively)

e. Pick up your pipette and hold it upright like mine and identify the mark at the upper part.

f. Dip it into the beaker of base and suck the liquid carefully, watching as the liquid moves up the pipette until it slightly passes the mark, stop and quickly cover the pipette by placing your index finger on the mouth I.e. the upper opening of the pipette. Carefully adjust the level to the mark by gently lifting your finger. Teacher gives them time to practice.

g. Empty the content into the conical flask labeled A. Repeat the action for two other flasks.

h. Put two drops of the methyl orange indicator into each of the content of the flasks. Shake the flasks, note any colour change and keep aside.

i. Draw the titre table and record the initial volume of acid before titration commences which is usually zero on the second line as shown. Teacher draws the sample of titre table on the board.

j. Begin to titrate the base with the acid from the burette gradually, watching out for any colour change which will mark the end point or neutralization point.

k. Read the volume of acid used as shown on the burette and record on the first line on the table under Readings as Final. Teacher asks a student to explain why it should be arranged like that? More explanations are given for better understanding.

l. Repeat the process for the content of the other two conical flasks, by either refilling the burette to zero level or continue from where he stopped if the volume of acid left will be sufficient.

m. Record the volumes of acid used.

n. Finally calculate the average titre volume by adding two or three concordant values and divide by two or three respectively.

Teacher explains further the technique of identifying concordant values and allows the students to practice with more examples.

Step V: Teacher and the lab. attendants go round continuously to supervise what the students are doing and effect corrections where necessary.

Step V1: Teacher allows them more time to round up and cross-check their work. On satisfaction, he instructs the students to

- submit their practical notes in their groups through the leader,
- clean up their tables and the apparatus used,
- stand beside their table for inspection by the lab. attendant.

Step VII: Teacher releases the reading assignment for students to prepare for next practical class; He tasks the group leaders to organize discursions, study with and read through pp. 94-96, pgfs 1-14 of Sanda, and pp.7-13, pgfs 1-14 of Eketunde and answer the assessment questions that follow.

1. Which aspect of chemistry practical is this called? titration or Volumetric analysis.
2. Mention two major reagents needed for this experiment? Acid and Base
3. List 6 major apparatus that will be used for the experiment.
4. Write the functions of the following apparatus; white tile, funnel and burette knob.
5. Give the reason why you should not blow into the pipette
6. Justify the reason for rinsing the burette with acid and the pipette with base before using them.
7. Mention three common indicators used for titration exercise.
8. What is the function of the indicator in neutralization process?
9. Why should the process be performed two or three times over?
10. What is the range for determining the concordance value? ±2,±3,±4
11. What assists you to avoid the error of parallax? meniscus

APPENDIX X1B

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on PB and TwA learning Approach for Practicals (TMIPB&TwALAP)

TEACHER'S MANUAL

METHOD: Problem-Based and Textbook-with-Assessment (PB and TwA) learning approach

LESSON: 2

CLASS: SS2

SUBJECT: Chemistry Practical

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES: At the end of the lessons, students should be able to:

ix. sign and collect complete apparatus they will require to carry out the titration exercise successfully.
x. Confidently clamp burette onto the iron stand firmly without breaking it.
xi. Pipette correctly required volume of acid into the conical flask without mistakenly sucking in the acid.
xii. Operate freely the control knob of the burette to let acid into the conical flask.
xiii. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
xiv. Observe promptly the end point or neutralization point of acid to base.
xv. Observe all precautions associated with the titration exercise.
xvi. Fill the titre table correctly.

PROCEDURE:

Step I: Teacher refers the students to the study questions given during the last practical lesson.

Step II: Teacher instructs the students to exchange their practical notes where they answered the assessment questions across groups (in order to avoid favoritism) and guides them to score themselves. He controls the students to supply answers to the questions and mark.

Step III: Teacher introduces the practical lesson for the day which is: Real Titration Practical Experiment. He then refers the students to Sanda, p.98, pgfs 19-21 and explains further what they are going to do. The laboratory attendants have provided each student a set of the apparatus required for the titration on their tables but deliberately skipping one important apparatus from each student e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle, labeled beakers containing acid and base, etc.

Step 1V: Teacher then announces that students cross check the set of apparatus provided for them to ensure they are complete and in good condition. By this the students refresh their knowledge of the list of the apparatus once more. The lab attendants complete the omissions and the students go on with the practical experiment given on p. 98 of Sanda, pgfs 20-21.

NOTE: The students are now using the correct concentration of acid and base for this titration as they have moderately mastered the use of the apparatus.

Step 1V: Teacher and the lab. attendants go round continuously to supervise what the students are doing and effect corrections where necessary. Also, the group members are encouraged to assist one another to learn the tasks.

Step V: Teacher explains further the technique of identifying concordant values and allows the students to go on.

Step V1: Teacher allows them more time to round up and cross-check their work. On satisfaction, he instructs the students to

- submit their practical notes through their group leaders,
- clean up their tables and the apparatus used,
- stand beside their table for inspection by the lab. attendant.

Step VII: Teacher releases the reading assignment and exercises for students to prepare for next practical class which is going to be the post-test examination.

Practice more using the table 4 on p.99 of Sanda and table 3 on p.17 of Eketunde:

i. the titre table format.

ii. Filling the table.

iii. Identifying the concordance values.

iv. Calculating the average titre.

v. Read the warnings on pgf.27,p.18 of Eketunde and take them to heart to guide your actions throughout titration exercises.

APPENDIX X1C

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on PB and TwA learning Approach for Practicals (TMIPB&TwALAP)

TEACHER'S MANUAL

METHOD: Problem-based and Textbook-with-Assessment (PB and TwA) learning approach

LESSON: 3

CLASS: SS2

SUBJECT: Chemistry Practical Post-test Administration

PERIOD: Double period

OBJECTIVES: To compare the performance of the students after the treatment with their performance before the treatment using the result of the pre-test taken earlier on.

PROCEDURE:

Step I: Teacher asks how many students did the reading assignment and are ready for the final test.

Step II: Teacher introduces the posttest examination by giving out the practical chemistry question papers to be distributed by the research assistants. The laboratory attendants have provided each student a complete set of the apparatus required for the titration on their tables e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle/labeled beakers containing acid and base, etc.

Step III: The manipulative skill test raters go to the group of five students they rated during the pre-test to observe and rate them for this post-test. At the end of the exercise, the students' practical exercise books are collected as well as the rating formats for each student.

CONCLUSION: Teacher scores and records the post-test.

APPENDIX X11A

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLP) Practicals

TEACHER'S MANUAL

METHOD: Conventional Method

LESSON: 1

CLASS: SS2

SUBJECT: Chemistry Practical

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES: At the end of the lessons, students should be able to:

i. Sign and collect complete apparatus they will require to carry out the titration exercise successfully.
ii. Confidently clamp burette onto the iron stand firmly without breaking it.
iii. Pipette correctly required volume of acid into the conical flask without mistakenly sucking in the acid.
iv. Operate freely the control knob of the burette to let acid into the conical flask.
v. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
vi. Observe promptly the end point or neutralization point of acid to base.
vii. Observe all precautions associated with the titration exercise.
viii. Fill the titre table correctly.

PROCEDURE:

Step I: Teacher inform of introduction tells the students that they are starting their practical chemistry practical today. He reminds the students of the safety measures to be observed in the laboratory during practical e.g., no eating nor drinking in the lab., rinse burette with small quantity of acid, pipette with base and the other apparatus with distilled water before using them etc.

Step II: Teacher who is the only person that has the practical chemistry apparatus shows the students each of the apparatus and makes them re-echo the name as he mentions it. e.g. pipette, burette, funnel, clamp and stand, conical flask, reagent bottle, labeled beakers containing acid and base required for the titration, etc.

Step III: Teacher then shows the students how the apparatus are being used. He then performs a Titration experiment while the students watch. He repeats the experiment two or three more times and records the titre values.

Step 1V: He teaches them how to average the values to arrive at the volume of acid used. He further talks about the reactions between acids and bases that leads to the neutralization points and shows them the colour changes when indicator was added and after neutralization has taken place.

CONCLUSION: Students may ask one or two questions and then copy the note the teacher will give.

APPENDIX X11B

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLP) Practicals

TEACHER'S MANUAL

METHOD: Conventional Method

LESSON:2

CLASS: SS2

SUBJECT: Chemistry Practical

PERIOD: Double period

INSTRUCTIONAL OBJECTIVES:

At the end of the lessons, students should be able to:

1. Write a correct list of the apparatus required to carry out titration exercise successfully.
2. Operate freely the control knob of the burette to let acid into the conical flask.
3. Operate freely the pipette to let base into the conical flask.
4. Correctly read the burette to the minimum cm^3 of acid into the conical flask.
5. Carry out the titration of any set of acid and base confidently with minimal supervision.
6. Observe promptly the end point or neutralization point of acid to base.
7. Work out and fill correctly on the table the average volumes of the acid used.
8. Observe all precautions associated with the titration exercise.

PROCEDURE

Step I: Before the practical chemistry period, the lab. attendants would set the apparatus that will be used for the day's practical. Teacher instructs that the students form groups of about ten on each set of the apparatus.

Step II: Teacher writes the titration instruction on the board, thus:

Burette readings (initial and final) must be recorded appropriately. Volume of pipette used must be recorded but no account of experimental procedure is required. All calculations must be done in your answer sheet.

The reagent A is 0.500 mol dm^{-3} solution of HCl acid. The reagent B is a solution of K0H containing 2.5g per $500cm^3$ solution.

Method; Put A into the burette and titrate it against 25.0 cm^3 portion of B using methyl orange indicator. Repeat the titration to obtain consistent titres. Tabulate your readings and calculate the average volume of A used.

Step III: Teacher instructs the students to follow the procedure he used during the previous week practical lesson to carry out the titration experiment.

NOTE: For this titration involving students, acidulated distilled water, pH scale 6 and highly diluted base, pH scale 8, are going to be used to prevent the adverse effect of unavoidable sucking and splashing of the chemicals which are common with first-time users of pipette and burette.

Step V: Teacher and the lab. attendants go round to supervise the students' activities and offer any necessary assistance and corrections,

Step VI: Teacher gives general corrections based on their observations from the students' activities.

Step VII: He then goes away and instructs the class captain to collect and bring their practical note books when they finish, clean out their environment and the apparatus used.

CONCLUSION: Teacher announces that the next practical lesson will be the post-test exam., to mark the end of the program, so students should prepare properly and go through everything they have been taught.

APPENDIX X11C

INSTITUTE OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN, NIGERIA

Treatment Manual of Instruction on Conventional Method of Teaching and Learning (TMICTLP) Practicals

TEACHER'S MANUAL

METHOD: Conventional Method

LESSON:3

CLASS: SS2

SUBJECT: Chemistry Practical

PERIOD: Double period

OBJECTIVES: Post-test Administration.

PROCEDURE

Step 1:

The lab. attendants supply every student the apparatus or reagents required for the titration exercise

Step II: Teacher releases the Practical CHEMAT for the post-test.

Burette readings (initial and final) must be recorded appropriately. Volume of pipette used must be recorded but no account of experimental procedure is required. All calculations must be done in your answer sheet.

The reagent A is a solution of trioxonitrate (V) acid containing 2.15g in $500cm^{-3}$ solution of acid. The reagent B is a solution obtained by taking $25cm^3$ of a saturated solution of potassium trioxocarbonate (1V) in $500cm^3$distilled water.

Put A into the burette and titrate it against 25.0 cm^3 portion of B using methyl orange indicator. Repeat the titration to obtain consistent titres. Tabulate your readings and calculate the average volume of A used.

Step III: Teacher and the lab. attendants go round to ensure that the students' are supplied all the apparatus and the reagents required.

Step 1V: As the students start working, the manipulative skill test raters begin to rate the students they rated during the pre-test. At the end of the exercise, the students' practical notebooks are collected as well as the rating formats.

CONCLUSION: Teacher scores and records the post-test.