



Re-structuring Secondary School Chemistry Education for National ... (Isa & Muhammad, 2021)

Re-structuring Secondary School Chemistry Education for National and Economic Development in Nigeria

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Abstract

This paper examines the need to re-structure of Secondary School Chemistry Education for National and Economy Development in Nigeria. Chemistry Education is considered as a key agent of development, either as a way of developing human capacity, increasing the skilled workforce for modernization, developing capability and empowerment. Nigeria, as a nation, is still wadding in a muddy pull in seeking for the right way to terminate her total dependence on foreign nations for technological expertise in fields of Science and Technology. The nation has produced many scientists, engineers and technologist yet we import services and goods in these fields from other countries which resulted in a recessed economy. This paper therefore discussed the loopholes in the present secondary school chemistry education and recommended the way forward in terms of restructuring the curriculum themes to produce a functional chemistry education, rebranding the chemistry practical activities to integrate improvisation with locally available materials and chemical processes designed to meet the need of the society (and not just rote learning of titration and cation/anion analysis of procured chemical compounds), introduction of remedial teaching plan for mastery learning strategy, introducing Science Mini Project (SMP) for Senior Secondary Students using available local materials as part of SSCE formative assessment scores. This would build a solid foundation that would usher in a new era of creative and innovative students who are prepared for post- secondary industrial work and at the same time could proceed with higher confidence and adequate creative potential and practical skills to higher education in any science and technological field.

Keywords: Secondary School Chemistry Education, Re-structure, Economy and National Development, Chemistry curriculum, Science Mini Project



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Introduction

Re-structure according to Eze, et.al. (2013) is a symbol with tremendous importance and this symbol can be expressed in different way. Rebranding on other hand is the process of changing the old methods of doing things and strategically creating a better attitude towards doing same thing for better image portrayal. Rebranding is the creation of a new name, term, symbol, design or a combination of them for an established brand with the intention of developing a differential (new) position in the mind of stakeholders and competition. According to Abubakar, etal (2012) "Re-structuring Nigeria simply means to redefine our concept of Nationhood and engage wholly in the process of National renewal to attain a height where National interest is exalted far above personal, ethno-religious and religious interest". These renewal changes are typically aimed at the repositioning of a brand, sometimes in an attempt to distance itself from certain negative connotations of the previous branding.

Chemistry Education is considered as a key agent of development, either as a way of developing human capacity, increasing the skilled workforce for modernization, or as a matter of personal freedom, developing capability and empowerment. Nigeria, as a nation, is still wadding in a muddy pull in seeking for the right way to terminate her total dependence on foreign nations for technological expertise in fields of Science and Technology. The nation has produced many scientists, engineers and technologist yet we import services and goods in these fields from other countries which resulted in a recessed economy.

Chemistry education is the study of the teaching and learning of chemistry in all schools, colleges and universities. Chemistry Education has also been identified to be one of the major bedrock for the transformation of a nation's economy. It is needed for the production of the needed technologists, technicians, engineers, medical practitioners who are required to turn the nation's economy around and usher in the desired technological advancement which is very much required for sustainable development.

National development has been defined as a development that meets the need of the present without compromising the ability of the future generation to meet their own needs. The concept of sustainable development emphasizes that education should be geared to prepare students to learn how to take responsibility for both themselves and their society for today and in the future (Ayodele, 2018). Burmeister, etal (2012), opined that all educational domains and all school subjects need to contribute to education for sustainable development including secondary school chemistry.

The position of Chemistry and the chemical industry according to Isa and Muhammad, (2019) in a nation play core roles in achieving Economic and national development. Chemical knowledge is necessary to understand issues that threaten the sustainability of our planets (global warming, ozone depletion acid rain formation, among others). Moreover, the chemical industry provides most of the raw materials necessary for every other type of business or endeavor. Chemistry is also the basis of a modern energy supply, agriculture, innovative materials, communication, biotechnology and pharmaceuticals.

Ayodele, (2018) and Isa and Usman (2021) opined that, students lack of interest in Chemistry is majorly as a result of the content of the syllabus and this has negatively affected their attitude generally to science subjects. Also, secondary school students perceived Chemistry syllabus as being too wide and involving too many calculations, Chemistry is been too abstract



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(Uchegbu, *etal* 2016; Muhammad & Isa 2018). Moreover, over the years the pass rates in Chemistry for most part have fallen below 50% (West African Examination Council, 2019). This poor performance could be as a result of lack of interest in the content and ineffective teaching methods used by the teachers.

According to Edomwomyi-Otu and Aava in Ayodele (2018) there is a significant positive relationship between interest and efforts on performance in Chemistry. If the students have interest in the subject, they would make effort to perform well in the subject. There is therefore a need to restructure the senior secondary schools chemistry syllabi in such a way that is not only meaningful but also re-awaken students interest in chemistry so to provide a solid foundation for vocations related field like health, pharmaceuticals, petroleum and petrochemical industries, agriculture, chemical engineering and so on.

Nigeria has dwelt in the realm of underdeveloped economy for too long, though the Nigerian economy is now referred to as a developing economy, yet Nigeria as a nation is still swaying in a blurry pool in seeking the right way to reduce or end her total reliance on foreign nations for goods and services in fields of Science and Technology. Nigeria needs to produce more graduates in these fields who are competent and have been adequately grilled with relevant curriculum tailored towards innovative and sustainable developmental goals in their respective fields of Science and Technology (Ayodele, 2018). Chemistry is a core science subject taught in the secondary school as prerequisite course for admission into tertiary institutions in these fields. Qualitative functional chemical knowledge is practical and useful but the Nigerian formal education has not provided school learners with functional education. The secondary school chemistry curriculum taught over the years has lost its relevance in this aspect. Most Chemistry students from secondary schools are not able to apply principles taught or how to relate the theories with the practical in everyday live or to view Chemical knowledge as a tool for wealth creation. There is therefore a need to review the curriculum for teaching Chemistry in the secondary school, to create a functional and relevant Chemistry curriculum that would meet the societal demand, awaken interest for the subject in students and aid the sustainability of scientific and technological development in the country.

In view of this, this paper proposes the re-structuring of the secondary school chemistry curriculum and education in terms of the objectives, themes and topics, practical syllabus and assessment. The paper highlights the loopholes in the Nigerian secondary school chemistry curriculum, it extrapolates the secondary school chemistry curriculum of the two most populous and technologically viable nations; china and India with that of Nigeria. The paper also proposed the way forward in terms of restructuring the themes, topics, method of instruction, content, scope and practical chemistry syllabus and also made some salient recommendations.

Objectives of the paper

1. To identify loopholes in the Nigerian secondary School Chemistry curriculum,
2. To propose ways of re-structuring the Secondary School Chemistry curriculum
3. To proffer appropriate recommendations.



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Contrast between Nigerian and Indian Secondary School Chemistry Objectives

A national development involves those activities, processes put in place to meet the need of the present, at the same time not sabotaging the future. China and India are the two most populous countries with high reliance on a lot of homemade chemical products and innovative technologies. Hence, the Nigerian secondary school chemistry curriculum is taken side by side with India in terms of objectives, and China in terms of themes and the three are contrasted in terms of practical syllabus in order to identify the loopholes in the Nigerian secondary school chemistry curriculum.

The Objectives of Chemistry Education in Nigeria National Curriculum for Senior Secondary Schools and that of India Secondary School Chemistry Curriculum are presented in the table below.

Table 1: Objectives of Secondary Chemistry Education in India and Nigeria

Indian Secondary School Chemistry Curriculum Objectives	Nigerian Secondary School Chemistry Curriculum Objectives
<ol style="list-style-type: none"> 1. To promote understanding of basic facts and concepts in chemistry while retaining the excitement of chemistry. 2. To make students capable of studying chemistry in academic and professional courses (such as medicine, engineering, technology) at tertiary level. 3. To expose the students to various emerging new areas of chemistry and apprise them with their relevance in future studies and their application in various spheres of chemical sciences and technology. 4. To equip students to face various challenges related to health, nutrition, environment, population, weather, industries and agriculture. 5. To develop problem solving skills in students. 6. To expose the students to different processes used in industries and their technological applications. 7. To apprise students with interface of chemistry with other disciplines of science such as physics, biology, geology, engineering etc. 8. To acquaint students with different aspects of chemistry used in daily life. 9. To develop an interest in students to study chemistry as a discipline. 	<ol style="list-style-type: none"> 1. Facilitating a transition from secondary to tertiary level of education in the use of scientific concepts and techniques acquired in chemistry. 2. Providing the students with basic knowledge in chemical concepts and principles, through efficient selection of content and sequencing. 3. Showing chemistry in its relationship with other subjects. 4. Showing chemistry and its links with industry, everyday life, hazards and benefits. 5. Providing a course which is complete for its pupils not proceeding to higher education while it is at the same time, a reasonably adequate foundation for a post-secondary course.

Source: (Indian Secondary School Curriculum 2015; Igwe, 2015)

The chemistry curriculum objectives as presented in the table 1 above revealed the inadequacy of the Nigerian objectives when compared with those of Indian secondary school chemistry curriculum. The India objectives are more relevant and designed to meet the societal needs while Nigeria objectives seemed ambiguous in comparison because in Nigeria the chemistry curriculum centered majorly to Facilitating a transition from secondary to tertiary level of



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education in the use of scientific concepts and techniques (Igwe 2015). According to Matazu (2010), though Nigeria is rich in human and natural resources, there are so many unemployed youths because the educational system does not equip them for self-reliance and does not expose the students to different processes used in industries and their technological applications. Teaching of chemistry in view of this should be practically oriented to develop skills needed for entrepreneurial development and at the same time for movement to higher education.

The objectives stated in the secondary school chemistry curriculum, did not make provision for relating chemistry to; nature and society, wealth creation, health and daily living and so on. Post-secondary chemistry students are not trained to engage in small scale analysis and production of household chemical products useful and relevant to the society. There is need to review the objectives of the present chemistry curriculum in Nigeria to enable students relate chemistry to nature and society, to equip students with adequate practical skills for functional chemistry that would make them work effectively as industrial technicians or chemical artisans for those who may not be opportune to proceed to tertiary education.

Contrast between the Themes of Chinese and Nigerian Secondary Chemistry Curriculum

The table below presents the themes of the secondary school curriculum of China and our nation Nigeria.

Table 2: Secondary School Chemistry Curriculum Themes for China and Nigeria Source; Nigerian Educational Research Development Council, NERDC (E-Curriculum, 2013-2014)

Themes of Chinese Secondary Chemistry Curriculum		Themes of Nigerian Secondary Curriculum	
Chemistry 1	1. Knowing Chemistry as a science 2. Basics to Chemical experiments 3. Common Inorganic Elements and compounds and their applications	Chemical World	Periodic table, Chemical reactions, particulate nature of matter, gas laws, chemical combinations, qualitative and quantitative analysis
Chemistry 2	1. Particulate Structure of Substances 2. Chemical Reaction and Energy 3. Chemistry and sustainable social development	Chemistry and environment	Separation techniques, acids bases and salts, non-metals and their compound.
Chemistry and Daily lives	1. Chemistry and Personal Health 2. Materials in Daily Lives 3. Chemistry and Environmental Protection	Chemistry and industry	Chemical industry, redox reactions and electrolysis, metals and their compounds, petroleum / crude oil
Chemistry and Technology	1. Chemistry and Exploitation and Application of Natural Resources 2. Chemistry and Manufacture and application of Materials 3. Chemistry and Industrial and Agricultural production	Chemistry of life	Carbon and its compound, Hydrocarbons, fats and oils, soap and detergents, giant molecules.
Particulate structure and Properties of Substance	1. Atomic Structure and Elements 2. Chemical Bonds and properties of substances 3. Intermolecular Forces and properties' of Substances 4. Values of Investigating Particulate Structure of Substances		



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Chemical Reaction Mechanisms	1. Chemical Reaction and Energy 2. Velocity of Chemical Reaction and Chemical Equilibrium 3. Ionic Equilibrium in Solution
Basic Organic Chemistry	1. Components and Structures of Organic Compounds 2. Properties and Application of Hydrocarbons and its Ramifications 3. Saccharine, Amino Acids and Protein 4. Synthesized Polymer Compounds
Experimental Chemistry	1. Basics to Chemical Experiments 2. Enquiry by Chemical Experiments

Chemistry education must contribute to developing a balanced and well-informed society as citizens responsible for how the present shapes the future. There is need to infuse themes and topics in the chemistry curriculum content, teaching and practice, so as to reveal the link of Chemistry to nature, society and everyday living. Also, directing the themes to subsume topics targeted at achieving a functional chemistry education for the good of the individual and the society at large. According to Burmeister et.al (2012), chemistry education that would achieve a sustainable development must focus on general educational skills for societal participation, it should deal with the impacts of development related to chemistry and technology on the ecology, the economy, and society at the local, regional and global level and develop skills in students to actively handle these aspects in the future.

Comparison of Chemistry Practical syllabus of India, China and Nigeria

Restructuring chemistry education towards a sustainable development in Nigeria requires a shift in not only the theoretical content but also the contextual approaches in teaching chemistry practical skills. The Secondary School Chemistry Practical syllabus for Nigeria, India and china are presented below:

Table 3: Comparison of Chemistry Practical Syllabus

INDIA	CHINA	NIGERIA
A. Surface Chemistry (a) Preparation of one lyophilic and one lyophobic sol Lyophilic sol - starch, egg albumin and gum Lyophobic sol - aluminium hydroxide, ferric hydroxide, arsenous sulphide. (b) Dialysis of sol-prepared in (a) above. (c) Study of the role of emulsifying agents in stabilizing the emulsion of different oils. B. Chemical Kinetics (a) Effect of concentration and temperature on the rate of reaction	D. Chemical Equilibrium One of the following experiments: a) Study the shift in equilibrium between ferric ions and thiocyanate ions by increasing/decreasing the concentration of either of the ions. . Quantitative Estimation i) Using a chemical balance. ii) Preparation of standard solution of Oxalic acid. iii) Determination of strength of a given solution of Sodium Hydroxide by titrating it against standard solution of Oxalic acid. iv) Preparation of standard solution of Sodium Carbonate. v) Determination of strength of a given solution of	1. Acid-base titration 2. Water of crystallization 3. Thermochemistry 4. Qualitative analysis involving cations Pb^{2+} , Cu^{2+} , Al^{3+} , Fe^{3+} , Mn^{2+} , Zn^{2+} , Co^{2+} , Ca^{2+} , Ba^{2+} , Mg^{2+} , and anions. SO_4^{2-} , SO_3^{2-} , NO_3^- , CO_3^{2-} , Cl^- , Br^- , I^- . Test for gases: CO_2 , NO_2 , H_2 , O_2 , SO_2 , NH_3 and H_2S .



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between Sodium Thiosulphate and Hydrochloric acid.

(b) Study of reaction rates of any one of the following:

(i) Reaction of Iodide ion with Hydrogen Peroxide at room temperature using different concentration of Iodide ions. (ii) Reaction between Potassium Iodate, (KIO_3) and Sodium Sulphite: (Na_2SO_3) using starch solution as indicator (clock reaction).

C. Thermochemistry Any one of the following experiments i) Enthalpy of dissolution of Copper Sulphate or Potassium Nitrate.

ii) Enthalpy of neutralization of strong acid (HCl) and strong base (NaOH). iii) Determination of enthalpy change during interaction (Hydrogen bond formation) between Acetone and Chloroform.

D. Electrochemistry Variation of cell potential in $\text{Zn}/\text{Zn}^{2+} \parallel \text{Cu}^{2+}/\text{Cu}$ with change in concentration of electrolytes (CuSO_4 or ZnSO_4) at room temperature.

E. Chromatography

i) Separation of pigments from extracts of leaves and flowers by paper chromatography and determination of R_f values.

ii) Separation of constituents present in an inorganic mixture containing two cations only (constituents having large difference in R_f values to be provided).

F. Preparation of Inorganic Compounds

i) Preparation of double salt of Ferrous Ammonium Sulphate or Potash Alum.

ii) Preparation of Potassium Ferric Oxalate.

G. Preparation of Organic Compounds Preparation of any one of the following compounds

i) Acetanilide ii) Di-benzal Acetone iii) p-Nitroacetanilide iv) Aniline yellow or 2 - Naphthol Aniline dye.

Hydrochloric acid by titrating it against standard Sodium Carbonate solution.

F. Qualitative Analysis (a) Determination of one anion and one cation in a given salt **Cations**- Pb^{2+} , Cu^{2+} , As^{3+} , Al^{3+} , Fe^{3+} , Mn^{2+} , Ni^{2+} , Zn^{2+} , Co^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} , Mg^{2+} , **Anions** - CO_3^{2-} , S^{2-} , SO_3^{2-} , SO_4^{2-} , NO_3^- , Br^- , I^- , PO_4^{3-} , CH_3COO^- (Note: Insoluble salts excluded)

(b) Detection of -Nitrogen, Sulphur, Chlorine in organic compounds.

b) Study the shift in equilibrium between $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and chloride ions by changing the concentration of either of the ions.

E. Quantitative Estimation

i) Using a chemical balance. ii) Preparation of standard solution of Oxalic acid. iii) Determination of strength of a given solution of Sodium Hydroxide by titrating it against standard solution of Oxalic acid. iv) Preparation of standard solution of Sodium Carbonate. v) Determination of strength of a given solution of Hydrochloric acid by titrating it against standard Sodium Carbonate solution.

E. Qualitative Analysis (a) **Determination of one anion and one cation in a given salt** **Cations**-

Pb^{2+} , Cu^{2+} , As^{3+} , Al^{3+} , Fe^{3+} , Mn^{2+} , Ni^{2+} , Zn^{2+} , Co^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} , Mg^{2+} ,

Anions - CO_3^{2-} , S^{2-} , SO_3^{2-} , SO_4^{2-} , NO_3^- , Br^- , I^- , PO_4^{3-} , CH_3COO^- (Note: Insoluble salts excluded)

(b) Detection of -Nitrogen, Sulphur, Chlorine in organic compounds



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H. Tests for the functional groups present in organic compounds:

Unsaturation, alcoholic, phenolic, aldehydic, ketonic, carboxylic and amino (Primary) groups.

I. Characteristic tests of carbohydrates, fats and proteins in pure samples and their detection in given food stuffs.

J. Determination of concentration/molarity of KMnO_4 solution by titrating it against a standard solution of: i) Oxalic acid, ii) Ferrous Ammonium Sulphate (Students will be required to prepare standard solutions by weighing themselves).

Source: (Indian sec. school curriculum 2015, 123-124; Ministry of Education MoE 2007, China; NERDC Federal Ministry of Education – Senior Secondary Education Curriculum Chemistry for SS1-3; 2010)

Ways to Re-structure Secondary School Chemistry Curriculum

1. Rephrasing the Objectives

Chemistry education should deal with the impact of chemistry on nature, environment, society at the local, regional and global level and also enlighten students on the impact of all these on the economy. We need our schools, universities and lifelong learning programmes to focus their objectives on science and technology with innovative, economic, environmental and social perspectives.

2. Functional Practical Chemistry

Practical topics should be drawn from topics taught in the syllabus like dilution and standardization of chemical solutions, neutralization, rates of reaction, solubility, thermochemistry, treatment of hard water, simple inorganic analysis; water analysis, soil analysis, identification of cations and anions in food substances and drinks, esterification, saponification, identification of functional groups. The practical questions for the SSCE or NECO could be drawn from the above listed topics using locally available materials e.g.

- i. Analysis of impure samples or mixtures like alum, ink or dye, ferrous sulphate tablet
- ii. Standardization of battery water.
- iii. Determination of pH of common drinks
- iv. Oxalate ions in fruits
- v. Study of reaction rates
- vi. Effect of temperature on some food preservatives
- vii. Separation of pigments from extracts of leaves and flowers by paper chromatography and determination of R_f values, and other relevant experiments.



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3. Improvisation of locally available materials for experiments

Improvisation and the use of locally available materials for practical experiments should be encouraged. The Nigerian chemistry curriculum could integrate improvisation on materials used. That is locally available chemicals could be used for some practical experiments. This would also create awareness of the chemical substances available around us, for example juices of unripe citrus fruits like unripe oranges, lemon e.t.c as sources of organic acids, potassium hydroxide from wood ashes, dyes of local plants (e.g *Hibiscus sabdariffa*; known as Zobo) as indicators for acid base titration, and so on. These materials could be used in acid-base titration, standardization and dilution processes.

4. Science Mini Projects (SMP)

Introduction of Science Mini Project (SMP) for Secondary School leaving Chemistry Students. The secondary school Chemistry curriculum for India and china both include chemistry projects on topics given to students to reveal the knowledge gained by the students in terms of application of principles and chemical procedure in analyzing or producing simple chemical compounds. This could be adapted in our secondary curriculum. A mini project could be given to students as part of the formative assessment score of the SSCE. e.g.

- i. Determination of pH in different water samples, juices, beverage drinks and the implication.
- ii. Production of soft soap from a locally available ester.
- iii. Extraction of essential oils and carrier oils from seeds, leaves and flowers and other project topics suggested by the students and teachers.

5. Introduction of Remedial Teaching Plan (Mastery Learning Strategy) For SSI and SSII

There have been various researches into reforming the dynamics of the classrooms and according to Ayodele (2018), every learner can attain mastery in any subject if given enough engaged-time. He opined that the difference in academic achievement is not just the IQ (intelligent quotient), but the amount of time students spend actively engaged on a given task. Hence, a Remedial Teaching plan in form of summer revision classes should be organized for SS1 and SS2 students who could not meet 50% pass mark in chemistry. This paper proposes a remedial teaching plan for SS1 students and SS2 student who could not meet up to 50% in their summative assessment in a particular subject. The remedial teaching could be for a month during the long holidays with the teachers acting as facilitators while the students are given revision exercises to work with and ask questions when clarifications are needed.

Conclusion

Chemistry is a major pillar needed to sustain the nation's growth in science and technology. The chemistry curriculum in Nigeria is not structured for a functional chemistry education that could transform and sustain development in science and technology. Hence, there is an undeniable need to re-structure our chemistry curriculum starting from secondary education. Re-structuring the chemistry curriculum would re-awaken the interest of students and reposition their attitude towards the learning and practice of chemical principles and concepts. This would definitely improve the



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standard of chemistry education in Nigeria and prepare the platform for economic growth and national development.

Recommendations

The following recommendations are provided:

1. Curriculum planners should come together to rebrand the chemistry curriculum in Nigeria starting from secondary schools.
2. Funding of secondary school laboratories should be a public/private partnership
3. Re-training of teachers; you cannot give what you don't have. Teachers should be retrained on how to use indigenous chemicals and improvisation with locally available materials to conduct some practical procedures.
4. Use of local materials and improvisation in practical curriculum
5. Constant review of chemistry curriculum to meet the challenges and demand of the nation industrial and or entrepreneurial development.
6. Monitoring committees should be constituted to oversee the science laboratory facilities in secondary schools they would also validate the science mini project of each school.

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