Journal of CUDIMAC (J-CUDIMAC) http://cudimac.unn.edu.ng/journals-2/
ISSN 0794-4764 (Print) ISSN 2651-6063 (Online)
Vol 5, No.1 2018

A Creative Approach to the Teaching of Integrated Science

By

Eugene U. Okorie, PhD

Abstract

This paper set out to answer two questions: *how can concepts in Biology, Analytical and Industrial processes be presented in integrated form to undergraduate students?* and *how can Junior Secondary School teachers lead their students, in hands-on learning activities to study environmental conservation and safety, and other concepts in integrated (Basic) Science in line with the philosophy, objectives and recommended pedagogical approach to integrated science? The paper illustrates how transpiration (a biology concept) is related to saponification (a chemistry concept) and industrial process (application of scientific knowledge and skills in the production of industrial good [soap]) to satisfy human need. The paper also illustrates how teachers can lead their students, in hands-on learning activities, to process degradable agricultural waste materials into useful chemical materials, and use them as resource materials for educational activities in schools.*

Introduction

With the introduction of Integrated Science into the Nigerian education system in the early 1970s, many Colleges of Education and Universities developed courses for Integrated Science Teacher Education, in an effort towards production of sufficient number of specialist Integrated Science teachers who are professionally qualified, competent, effective and with the right attitude to the job. In the University of Nigeria, Nsukka, Integrated Science programme for undergraduate student teachers includes courses in Biology, Chemistry and Physics, usually regarded as Basic Sciences. Courses are also drawn from Astronomy, Space Science, Biochemistry and other subject areas. For instance, the programme has Industrial Processes and Analytical Processes, which are chemistry courses.

Inyang (2005) examined the Integrated Science teacher-trainee programmes of the various universities and recommended that the programmes should be structured such that Integrated Science is combined with Biology, Chemistry or Physics, as is the case in Colleges of Education. The author argued that

> a combined honour degree [in] integrated science and a basic science subject will enable a teacher who wishes to undertake a master's degree in science education with integrated science or any basic science option to do. Because of the broad based nature, the problems of confining integrated science graduates to the junior secondary schools, which make them feel inferior to the other science graduates who teach up to senior secondary. It will enable

integrated science graduates [to] teach the other basic sciences (Biology or Chemistry or Physics).

Irrespective of their stand on the structure of the Integrated Science programmes, one common feature to the Integrated Science programmes in Teacher training institutions in Nigeria is that the subject is organized in such a way that students who successfully completed the programme should be knowledgeable, in both content and pedagogy of aspects of science. However, they are not considered specialists in any of these branches of science from where courses were drawn to constitute the subject of Integrated Science.

In other words, they are not majors in any of the sciences say, Astronomy, Biology, Chemistry, Physics, Space science, etc. that constitute the subject of integrated science. The students, however, are expected to be conversant with how each of the subjects interrelates with the other subjects. Therefore, the integrated science undergraduate student teachers who studied analytical and industrial processes, for instance, which are mainly Chemistry courses, are not in any way chemistry majors. Therefore, they are not expected to be analytical chemists or industrial chemists per se. However, they are expected to teach concept in these aspects of Chemistry in integrated form to secondary school students, in a manner that shows the interrelatedness of the concepts with those of other sciences, say biology, physics, biochemistry etc., in explaining certain phenomena in nature to the students, in line with the philosophy and objectives of science education of Nigeria’s National Policy on Education.

Section 7, Article 39(a) of the National Policy on Education (Federal Republic of Nigeria (FRN, 2004) stipulates that science education shall emphasize the teaching and learning of science process and principle. This will lead to fundamental and applied research in the sciences at all levels of education; while article 39 (b) of the same section spelt out that the goals of science education shall be to:

(i) cultivate inquiring, knowing and rational mind for the conduct of a good life and democracy;
(ii) produce scientists for national development;
(iii) service studies in technology and the cause of technological development; and
(iv) provide knowledge and understanding of the complexity of the physical world, the forms and the conduct of life.

Because of the way integrated science programme is structured, especially in the Nigerian education system, some people now see it as the New Science, which Okorie (2011) described as a new body of knowledge, which develops the learners’ natural curiosity and inventiveness while maintaining in the individuals a sense of wonder about their environment, the world around them. It is a course that helps the learners to appreciate how science leads to and supports the development of technology; and how technological needs lead to new scientific discoveries that determine how we live in our rapidly changing world. The New Science is designed to serve the interests of a wide variety of students, those who have eye on science-related fields; those who need it for workplace requirements, etc. The New science has connections with other disciplines all geared towards the sustainable development of the human society.

The Problem

The undergraduate programme for integrated science student teachers has several courses drawn from various branches of science including Astronomy, Biology, Chemistry, Physics, Space Science, etc. It is expected that students who successfully completed the programme should be knowledgeable; able to demonstrate fundamental science process skills required of those who studied science and able to teach basic science to secondary school students and make the young learners appreciate the interrelatedness of aspects of science in understanding certain phenomena. Stated in the interrogative, the problem of this paper is: How can concepts in Biology, Analytical and Industrial processes be presented in integrated form to undergraduate students in line with the philosophy, objectives and methods of integrated science? And: how can Junior Secondary School teachers lead their students, in hands-on learning activities to study environmental conservation and safety, and other concepts in integrated (Basic) Science in line with the philosophy, objectives and recommended pedagogical approach to integrated science?

The Purpose

The purpose of this paper is to present concepts in Biology, and Industrial processes as concepts that are interrelated, to undergraduate students who are not Biology or Chemistry majors per se, so as to make meaningful instruction. Specifically, it is to

i. illustrate how the two science concepts: transpiration and saponification could be taught in integrated form in the industrial process of the manufacture of 'black soap';
ii. illustrate how teachers can lead their students, in hands-on learning activities, to process degradable agricultural waste materials into useful chemical materials, and use them as resource materials for educational activities in schools.

Chemical principles underlying the processes involved in the manufacture of local black soap

Soap is a mixture of sodium or potassium salts of carboxylic acid mainly palmitic acid [$CH_3(CH_2)_{14}COOH$] and stearic acid [$CH_3(CH_2)_{16}COOH$]. The soap is formed when the potassium salts are mixed together with vegetable oil and boil in a process called **saponification**. Saponification is the base-catalysed hydrolysis of carboxylic esters. Esters are compounds that result when the hydrogen atom **H** of an –OH acid is replaced by an **R** group (Bettleheim & March, 1991). Potassium is one of the necessary elements to plants. Plants obtain their potassium needs from the soil through the process of **transpiration**. Potassium, usually in form of ions in salt solution, is absorbed from the soil by the plants' roots. The rate of salt uptake by the roots depends on the rate of transpiration. Ewar and Hall (1975) observed that a plant with well aerated root system and low rate of transpiration will take up ions more rapidly than a plant with badly aerated roots and high rate of transpiration. In oil palm

(Elaeisguineensis), potassium is present throughout the plant and its presence can be detected by burning, during which process the potassium compound is converted to the oxide, which combines with carbon dioxide to form potassium carbonate (K_2CO_3) in the wood ash. Goddard and Hutton (1961) noted that in early times potassium carbonate was 'the only alkaline substance available for making soap or glass.'

Stages of experimental work

Several stages of experimental work are carried out. The first stage corresponds with a process in heavy (basic) chemical industry, which produces chemicals used as raw materials for other industries. In this case, the raw material is K_2CO_3.

Stage 1:

Oil palm materials (bunch, florescence, stem, etc.) are burnt to ashes, to convert the potassium content into the oxide, and then the carbonate.

$$4K + O_2 \longrightarrow 2K_2O \qquad (1)$$

$$K_2O + CO_2 \longrightarrow K_2CO_3 \qquad (2)$$

The reactions above are essentially oxidation.

Ibole (1986) showed that the filtrate of ashes of oil palm materials dissolved in deionised water, on normal chemical analysis, yield among other radicals K^+ and CO_3^{2-}, which confirm that the solution is essentially that of K_2CO_3.

Stage 2:

Solution of the ash of oil palm materials is alkaline and dark. It is therefore filtered several times to get a clear ash solution. The solution ($K_2CO_3 + H_2O$) is heated in an open vessel. A reaction occurs in which potassium hydroxide and carbon dioxide are produced. The carbon dioxide goes off while the potassium hydroxide remains in solution.

$$K_2CO_3 + H_2O \xrightarrow{\text{Heat}} 2KOH + CO_2\ (g) \qquad (3)$$

The reaction is essentially hydrolysis of the potassium carbonate. The potassium hydroxide (basic chemical) produced at this stage is the alkaline solution needed for the manufacture of the soap.

Stage 3:

The potassium hydroxide solution requires a suitable fatty acid, usually that of vegetable oil, for example, palm kernel oil (PKO) or palm oil, which contains more unsaturated hydrocarbon chain. Palm oil is used in making soaps **(**Encyclopædia Britannica, 2009). In West Africa, particularly Nigeria, palm oil is used in traditional soap making. If palm oil, (which is red in colour) is used as the source of fatty acid, the palm is bleached, by boiling it in an open pan until the red colour disappears, leaving pale, almost colourless oil. The colour is oxidized and removed in this oxidation process.

Stage 4:
The potassium hydroxide solution is boiled for some time, to concentrate it to the desired quality (1275 SG). The bleached palm oil is gradually poured into the boiling potassium hydroxide solution, while stirring goes on simultaneously. Palm oil contains palmitic acid (hexadecanoicacides) also known as tristearin, which when boiled with the potassium hydroxide is neutralized to yield the soap. The reaction is an endothermic reaction and this explains why the reaction mixture of potassium hydroxide and palmitic acid is kept boiling in the course of the reaction. The soap produced in this process is a mixture of potassium salts, and it is generally soft and more soluble in water (than say that of sodium salts).

Equation of the Reaction
The equation of the reactions carried out in the processes described above is:

$$\underset{\text{Stearic acid}}{C_{17}H_{35}COOH} + \underset{\text{potassium Hydroxide}}{KOH} \longrightarrow \underset{\text{Soap}}{C_{17}H_{35}COOK} + \underset{\text{Water}}{H_2O}$$

or

$$\begin{array}{l} CH_2OOCC_{17}H_{35} \\ | \\ CHOOCC_{17}H_{35} \\ | \\ CH_2OOCC_{17}H_{35} \end{array} + 3KOH \longrightarrow \begin{array}{l} CH_2OOCC_{17}H_{34}K \\ | \\ CHOOCC_{17}H_{34}K \\ | \\ CH_2OOCC_{17}H_{34}K \end{array} + 3H_2O$$

Lessons from this approach of presenting integrated science concepts
This study has illustrated how *transpiration* (a biology concept) is related to *saponification* (a chemistry concept) and industrial process (application of scientific knowledge and skills in the production of industrial good (soap) to satisfy human need). The method employed in this study is worthy of note. It placed emphasis on the application of physical method for qualitative identification of materials, and not on elaborate and lengthy chemical tests, which may not be possible in secondary schools where laboratory facilities for carrying out such tests are usually not available. Teachers could adopt this approach in presenting lessons on environmental conservation and safety to junior secondary school students.

Teaching the concepts of environmental conservation and safety
In teaching these concepts, the teacher should draw the attention of the students to the fact that Nigeria, at its present stage of development, is an agrarian nation and generates several tons of agricultural wastes annually. Some of the common agricultural wastes in Nigeria include Cocoa Pod, Pumpkin Pod, Oil Palm florescence, and plantain peels. These and other agricultural wastes materials could serve as a source of very useful inorganic chemical materials to teach Basic Science concepts. Therefore, the waste materials could be converted to wealth, if properly

managed, instead of allowing it to litter the streets and market places, which is the case in many of the communities. Thus, environmental pollution could be controlled while conserving the environment and making it safe for human habitation.

Presenting lessons on environmental conservation and safety to junior secondary school students

Step I Introducing agricultural waste materials

i. Lead the students to see agriculture as a very important occupation of the people of Nigeria. Let the students see the various benefits derived from agriculture.
ii. Show that Nigeria, at its present stage of development, is an agrarian nation and generates several tons of agricultural wastes annually.
iii. Enumerate some of the common agricultural wastes in Nigeria including Cocoa pod, Pumpkin pod, Oil palm florescence, and plantain peels.
iv. Explain that these and other agricultural wastes are degradable materials. Teach the concept of degradable waste material.
v. Explain that some degradable waste materials can serve as sources of very useful inorganic chemical substances for learning Basic Science concepts.
vi. Therefore, the waste could be converted to wealth, if properly managed.

Step II Proper waste management

Using relevant illustrations and photographs, explain the following activities involved in proper waste management:

i. collection of waste materials;
ii. transport of waste materials;
iii. processing or disposal of waste materials; and
iv. managing waste materials.

Step III Practical Hands-on Activities

Lead the students to nearby farms in the community or school garden to carry out the following activities (a), (b) and (c):

Activities (a)

i. collection of waste materials,
ii. transport of waste materials.

Activities (b) **-** Processing of waste materials (1)

Lead the students to carry out the following activities involved in processing of agricultural waste materials for educational purposes:

i. cutting the waste materials, e.g. plantain peels into small pieces;
ii. drying the pieces of plantain peels in the sun.

Activities(c) **-** Processing of waste materials (2)
Using a grinder, lead the students to crush the dry agricultural waste into powder form for use in the classroom or school laboratory for other lessons in Basic Science.

Step IV Using agricultural waste materials to enhance teaching-learning process in Basic Science

i. Present the chart [Appendix A] that summarizes the activities done so far, and see what other activities that should be carried out.

Step VI Evaluation

The teacher should note that this lesson with its activities, would last for a number of days, especially because agricultural materials require a lot of time to dry well. The teacher has to decide how many of the teaching steps will be covered adequately in a period, and evaluate each part of the lesson for a given period accordingly. The evaluation tips in the curriculum will greatly help the teacher in this regard.

References

Encyclopædia Britannica (2009). Oil palm. *Encyclopædia Britannica 2009 Student and Home Edition.* Chicago: Encyclopædia Britannica.

Ewar, D. W. and Hall, J. B. (Eds) (1975). *Ecological Biology 1 Organisms and their environment*. London: Longman Group Limited.

Federal Republic of Nigeria (FRN) (2004). *National Policy on Education* (4th Edition). Lagos: Federal Government Press.

Goddard, F. W. and Hutton, K. (1961) *Chemistry School Chemistry for Today*. London: Longmans, Green and Co Ltd.

Ibole, P. M. (1986). Chemical analysis of local materials and their application to the study of O'Level chemistry and the society. Unpublished chemistry exhibition project, Government Secondary School, Owerri.

Inyang, N. E. U. (2005). An appraisal of the professional preparation of quality integrated science teachers in Nigeria. Proceedings of 46th annual conference of Science Teachers Association of Nigeria, 242 – 247.

Okorie, E. U. (2011). Curriculum and the new science teacher: laying a firm foundation for the study of the new science in Nigerian schools. *Journal of Curriculum Studies*, 18(1), 163-168.

TEACHING ENVIRONMENTAL CONSERVATION: FROM WASTE TO WEALTH APPROACH © E. U. Okorie 2013

Activity

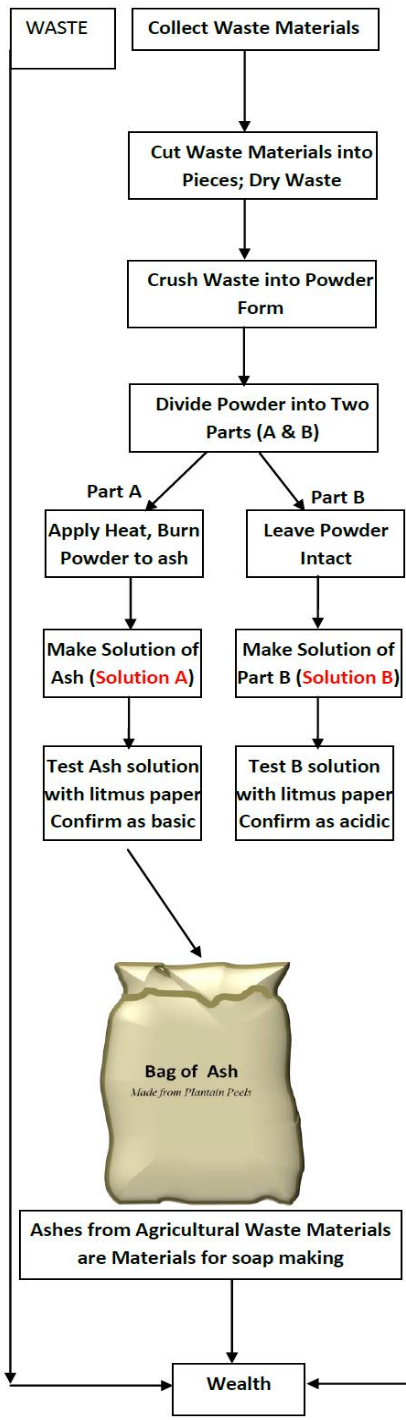
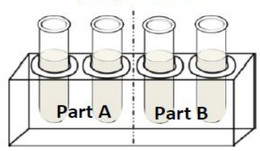


Diagram	Concept to Teach/ Lesson to Learn	NERDC Curriculum Reference
	Waste Management/ Sanitation	JS1, P3
Dry Waste in the sun. 	Sun as the Source of Heat Energy; Renewable Energy.	JS1, P2 JS1, P12
Crush Waste into Powder Form 	Mechanical Energy used by Machines and Grinding	JS1, P12
 Part A Part B		
Part A undergoing heating 	Uses of Energy; Effect of Heat on Solution/ Change of State of Matter; Biodegradable Material.	JS1, P12 JS1, P7
Make solutions of burnt Part A (ash) & Part B  Part A Part B	Soluble and insoluble substances	
Solution A Solution B  Basic Acidic	Acids and Base; Effect of Acids and Bases on Litmus Paper.	
 Local Soap Making	Resources Obtained from non-living things, Soap Making (Saponification), Uses and importance of non-living matter.	JS1, P3 JS1, P9