CONTENTS

EDITORIAL
ACRICE-3 is coming 1
Temechegna Engida

RESEARCH PAPERS
Hybrid orbitals notation: Some misconceptions in an undergraduate basic chemistry course 2
Robson Fernandes de Farias

Hybridization and molecular geometry: A number game 9
Lokendra Kumar Ojha

Practices and challenges of implementing locally available equipment for teaching chemistry in primary schools of North Shewa Zone in Amhara Region 17
Demisachew Shitaw

Contextualization and interdisciplinarity in chemistry teaching in Brazil: After two decades, everybody knows but nobody understands 31
Hoziam H.X. Rocha, a Deyse de S. Dantasb and Robson Fernandes de Farias

Untangling chemical kinetics through tangible and visual representation of matter 37
C. G. Kerstiens, D. C. Sisniegab, A. Gomez, B. M. Gunna, J. E. Becvara and M. Narayana

Evaluating the impact and potential of the chemical sciences in catalyzing the economic development through potential chemical entrepreneurship in Lesotho 46
Mosotho J. George and Thembi Setubatuba

Class attendance and academic performance of second year university students in an organic chemistry course 63
Ayodele Olufunmilayo D.

The need for a “Bologna declaration” pronouncement for Africa’s chemistry programs at tertiary levels 76
Fikru Tafesse and Malose J. Mphahlele

Comparative assessment of university chemistry undergraduate curricula in South-Western Nigeria 92
Modupe M. Osokoya, Isaac S. Fapuro and H. Oluwatola Omoregie

FEATURE ARTICLES
Incidence of biogenic amines in foods: implications for The Gambia 112
Oladele OYELAKIN and Anthony ADJIVON

GUIDELINES FOR AUTHORS 117
EDITORIAL

ACRICE-3 IS COMING

Temechegn Engida
Email: temechegn@gmail.com

Dear AJCE Communities,

The African Conference on Research in Chemistry Education (ACRICE) is FASC’s official conference on chemistry education. ACRICE conference is intended as a platform for understanding and enriching education for preparation of African citizens who are able to deal with local and global challenges. To that end, educators and researchers at all levels are invited to share vital knowledge and strategies for teaching and learning in culturally responsive ways.

ACRICE-1 was held in Addis Ababa/Ethiopia in collaboration with the Department of Chemistry of the Addis Ababa University from 5-7 December 2013. The presentations at the Conference were reviewed and published as special issues of AJCE under volume 4, numbers 2 and 3 (http://faschem.org/node/5).

ACRICE-2 took place at the University of Venda (South Africa) from 29 November to 4 December 2015. ACRICE-3 is planned to take place in Setif/Algeria from 8 to 10 October 2017 in collaboration with the Algerian Chemical Society.

While inviting you to participate in ACRICE-3, we hope you will enjoy reading the 1st issue of AJCE 2017 on various topics in Chemistry Education in Africa and elsewhere.

SJIF IMPACT FACTOR EVALUATION [SJIF 2012 = 3.963]
HYBRID ORBITALS NOTATION: SOME MISCONCEPTIONS IN AN UNDERGRADUATE BASIC CHEMISTRY COURSE

Robson Fernandes de Farias
Universidade Federal do Rio Grande do Norte, Cx. Postal 1664, 59078-970, Natal-RN, Brasil.
E-mail: robdefarias@yahoo.com.br

ABSTRACT

This work reports a study performed involving 26 students of an undergraduate basic chemistry course class at Federal University of Rio Grande do Norte, Brazil. The study was performed in order to evaluate the misconceptions about hybridization that students bring from high school courses and how to overcome such misconceptions. Methane, ammonia and water molecules were employed as examples. The equation was introduced in order to promote a most profound and mature interpretation of the hybridization notation. The sp4 and sp\textsuperscript{2.3} water hybrid orbitals were used to illustrate the interpretation that can be given to the n value. In the same direction, a graphic “paint analogy” was employed to give a proper interpretation to the n value. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

Despite some criticism [1], atomic hybrid orbitals still have a role to perform in chemistry [2], in both research and teaching. In high school chemistry courses, hybridization is a theme that is a little confusing to most of the students. In undergraduate chemistry courses (general chemistry), such theme is introduced a second time, with no different approaches. Note that, in Brazil, the general chemistry textbooks are translated, generally, from American editions, from several authors (James Brady, Peter Atkins, Theodore Brown, etc.) and, in such textbooks, the subject hybridization is presented in a similar manner as it is presented in high school chemistry textbooks of Brazilian authors.

In such texts (both, high school and college chemistry), an interpretation to the notation sp³ is that it represents four hybrid orbitals, made by the “mixing” of one s and three p orbitals. That is, the subscript 3 represents the number of p orbitals involved in the hybridization. However, this is a misinterpretation. For example, if the previous interpretation was right, the hybridization of nitrogen (in ammonia), and oxygen (in water), must be sp³ too, but this is not the case.

The present work reports a study performed involving 26 students of a undergraduate basic chemistry course class at Federal University of Rio Grande do Norte, Brazil. The study was performed in order to evaluate the misconceptions about hybridization that students brings from high school courses and how to overcame such misconceptions.
METHODOLOGY

The study was conducted along the first semester of 2016 with 26 students of an undergraduate basic chemistry class at Federal University of Rio Grande do Norte, Brazil. The subject hybridization was introduced as part of the chemical bond study, specifically the covalent bond type (employing the valence bond theory). The subject was introduced, as classically done, by considering the hybridization of carbon, in methane (CH4, sp3).

First, it was verified that to all students, hybridization was understood as a physical phenomenon. It was necessary to explain/clarify that hybridization is, in fact, a post facto manipulation of the atomic orbitals wave functions, in order to obtain “suitable” combinations (hybrid wavefunctions, associated with hybrid orbitals) that can, in the methane case, for example, account to the number of formed bonds, as well as the molecular geometry.

As a first approach to promote a most profound and mature interpretation of the hybridization notation, it was asked to the students what was the hybridizations of carbon (in methane), nitrogen (in ammonia) and oxygen (in water).

Repeating what they have learned in the high school textbooks (and what it is presented in many college basic chemistry textbooks, too), they stated that, in all three cases, the central atom exhibited a sp3 hybridization.

The three considered molecules where chosen taking into account that carbon, nitrogen and oxygen have increasing atomic numbers (6, 7 and 8, respectively), and that, in all three molecules, there is a total of four electrons pairs around the central atom. So, for the three considered molecules, four hybrid orbitals are employed, all of them been “constructed” from one s and three p atomic orbitals (2s and 2p orbitals). 


However, as is known, a sp3 hybridization is associated with a tetrahedral geometry/angle (109.5°). So, the challenge presented to the students was: if in ammonia the bond angle is 107° and in water the bond angle is 104.5°, how the hybridization could be of the sp3 type?

Two thirds of the students have so employed the valence shell electrons pair repulsion (VSEPR) theory in order to explain the “deviations” shown by ammonia and water in relation to the 109.5° tetrahedral angle, arguing that the hybridization in such molecules are, anyway, sp3.

At this point, the following formula was introduced to the students:

\[ n = \lambda^2 = -1 / \cos \theta \]  

in which \( \theta \) is the angle between the hybrid orbitals. This formula provides the \( n \) value in sp\(^n\) hybrids orbitals.

It must be emphasized here that, despite the fact that this equation comes from a higher level chemistry, there is no reason to, in an undergraduate course, to present and use this equation and its consequences to the interpretation of hybridization, providing, in a freshman chemistry course, a most profound and mature analysis of the chemical bond theories than that previously presented in high school chemistry courses/textbooks. In order words, the undergraduate basic chemistry courses must not be a simple “repetition” and “reinforcement” of the high school

Figure 1. Hybrid orbitals to ammonia (left) and water (right) molecules (reproduced from: http://courses.chem.psu.edu/chem210/mol-gallery/hybridization/hybrids.html).
teaching and (unfortunately) misunderstandings, misconceptions and misinterpretations of chemistry concepts and theories.

If the bond angles 109.5°, 120° and 180° are applied in the previous equation, the calculated n values are 3, 2 and 1, respectively, providing the sp3, sp2 and sp well known hybrid orbitals (tetrahedral, trigonal planar and linear molecular geometry, respectively), for which the value of n really coincides with the number of p orbitals involved in the hybridizations.

However, in water, for example, the two orbitals involved in the O-H bonds exhibits a sp4 hybridization. So, how them (students) explain that? In ammonia, the 107° bond angle provides a sp3.42 hybridization to the orbitals involved in the N-H bond formation.

All students gets very surprised with this results, not only to the fact that a number higher than 3 was obtained, but also to the fact that, as shown to ammonia, a not integer n value can be obtained. At this point, the following formula was presented:

\[
\cos \alpha = -1/(m.n)^{0.5}
\]

that provides the angle (α) between two hybrid orbitals: spm and spn. It can be verified that, when m = n, if m = 3, 2 or 1, the calculated values to α will be, of course, 109.5°, 120° and 180°. The hybridization to all orbitals in ammonia and water are shown in Figure 1.

RESULTS AND DISCUSSION

Since the bond angles are reliable and well stablished experimental data, the maxima that “against facts there are no arguments”, was used in order to convince the students that the calculated values were correct and then, that a new physical explanation/interpretation must be provided to the n value in spⁿ hybrid orbitals.
It must be stated here that convince the students to change the high school interpretation of the value of n in sp^n hybrid orbitals as the number of p orbitals employed in the hybridization, was not an easy task. It was possible to perceive that many students “accept” what the teacher is saying, but are not “really convinced”.

Such resistance to new ideas or new interpretations of “old” ideas is not an exclusive feature of the freshman student profile. Instead, it is a recurrent fact in science. However, taking into account that the “new” ideas considered here, are, in fact, an established chemical model, the “resistance” must be overcame, in order to achieve a really undergraduate level teaching/learning process.

The apparent difficulty, in the present study, was related with the counterintuitive nature of the obtained results: how could three 3 p orbitals give raise to sp4 hybrid orbitals? However, the counterintuitive nature of this result is consequence, of course, of the misinterpretation employed in the high school courses/textbooks and (unfortunately) reinforced in many undergraduate courses and textbooks.

In CH4, NH3 and H2O there are only three p orbitals involved in the hybridization. So, the superscript on p must be associated with another meaning: it is related with the percentage of p character (that is, the “contribution” of the three p orbitals) of the hybrid orbitals. So, a sp3 orbital has (1/4)x 100 = 25% of s-character and 75% of p character. In water, the hybrid orbitals involved in the O-H bond has (1/5) x 100 = 20% of s character and 80% of p character. On the other hand, the orbitals associated with the electron lone pair have (1/3.3)x 100 = 30.3% of s character and 69.7% of p character. So, one s orbital and three p orbitals could be combined in any proportion, in order to produce hybrid orbitals.
An analogy that was employed in the classroom and well received for all students was to compare the pure s and p orbitals with cans of paint: the s orbital is a can of black paint and the three p orbitals are three cans of white paint. In the sp3 hybridization (CH4, for example), the four resulting cans of paint have all the same color (that is, the same proportion of black and white paints).

To water, the black paint (s orbital, in the analogy), and the white paint (p orbitals) where mixed in different proportions, resulting in two orbitals with minor s character (sp4) and two orbitals with higher s character (sp2.3). The graphic analogy employed in the classroom is shown in Figure 2. A similar graphic analogy was employed to illustrate the hybrid orbitals to ammonia.

The “paint analogy” was chosen taking into account that paint of different colors can be mixed in any proportion (like the pure orbitals to produce hybrid ones), but only certain proportions are able to produce certain resulting colors (such as only certain combination of pure orbitals can produce hybrid orbitals that accounts to the experimental bond numbers and geometry of a given molecule).

![Figure 2. Graphic analogy employed in the classroom to illustrate the contribution of one s orbital and three p orbitals to the formation of four hybrid orbitals in methane (sp3) and water (sp4 and sp2.3)](image)

REFERENCES
HYBRIDIZATION AND MOLECULAR GEOMETRY: A NUMBER GAME

Lokendra Kumar Ojha
Lovely Professional University, Punjab
Email: ojha.lokendra@gmail.com

ABSTRACT

Present article emphasize the new pedagogy to learn the hybridization and molecular geometry. It is always a challenge for the students to remember the hybridization and geometry of the molecule correctly. This topic has several importance in subjective and objective type questions and answers since in most of the competitive examination hybridization and molecular geometry always comprise a huge number of questions. Now in order to remember all the hybridization, this paper gives you a table of few numbers and those number are also no need to remember because they contain certain trends in period and column (subtract 8 in row and subtract 6 in column) and certainly the table will form. Here, the more focus on the domain number (total bond pair and lone pair) 6, 5 and 4 because these domain number contain various type of geometry. This article is not emphasizing the theory behind the hybridization, but only on how to remember different hybridization and their geometry as far as the competitive skill is concerned. It has also some of the restrictions (limitation) and may not work for some of the coordination complex and inorganic compounds. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

Although the idea of orbital overlap allows us to understand the formation of covalent bonds, it is not always easy to extend these ideas to polyatomic molecules. When we apply valence-bond theory to polyatomic molecules, we must explain both the formation of electron-pair bonds and the observed geometries of the molecules.

The famous chemist Linus Pauling first developed the hybridization theory in 1931 in order to explain the structure of simple molecules such as methane (CH₄) using atomic orbitals [1]. Pauling explained this by supposing that in the presence of four hydrogen atoms, the s and p orbitals form four equivalent combinations or hybrid orbitals, each denoted by sp³ to indicate its composition, which are directed along the four C-H bonds [2]. Hybridization happens when atomic orbitals mix to form new atomic orbitals. The new orbitals have the same total electron capacity as the old ones. The properties and energies of the new, hybridized orbitals are an 'average' of the original un-hybridized orbitals.

METHODOLOGY

In this methodology, only two numbers are taken into account and the rest of the numbers have certain trends in row and column. The row will start from number 48, and 6 is subtracted in row and 8 is subtracted in column.

For hybridization

In order to calculate the hybridization, we only need to sum the bond pair and lone pair. If the sum is equal to 2, then it is sp (one for s and one for p), and if it is equal to 3, then it is sp² (one for s and two for p) and so on.
Table 1: For hybridization

<table>
<thead>
<tr>
<th>Bond pair + Lone pair</th>
<th>Hybridization</th>
<th>Bond pair + Lone pair</th>
<th>Hybridization</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>sp</td>
<td>5</td>
<td>sp^3d</td>
</tr>
<tr>
<td>3</td>
<td>sp^2</td>
<td>6</td>
<td>sp^3d^2</td>
</tr>
<tr>
<td>4</td>
<td>sp^3</td>
<td>7</td>
<td>sp^3d^3</td>
</tr>
</tbody>
</table>

For e-pair geometry and hybridization

In order to find the e-pair geometry (molecular geometry), you only need to remember the numbers (total valence shell electron, TVE) given below. For example, any compound which has TVE equal to 40, it is always trigonal pyramidal and if it has TVE equal to 28, then it is T shaped and so on.

Table 2: For hybridization and e pair geometry

<table>
<thead>
<tr>
<th>Domain 6</th>
<th>Domain 5</th>
<th>Domain 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVE</td>
<td>e-pair geometry</td>
<td>Hybridization</td>
</tr>
<tr>
<td>48</td>
<td>Octahedral</td>
<td>sp^3d^2</td>
</tr>
<tr>
<td>42</td>
<td>Square Pyramidal</td>
<td>sp^3d^2</td>
</tr>
<tr>
<td>36</td>
<td>Square Planer</td>
<td>sp^3d^2</td>
</tr>
<tr>
<td>22</td>
<td>Linear</td>
<td>sp^3d</td>
</tr>
</tbody>
</table>

Domain 4, 5 and 6 represent the coordination number of the central metal like if it is PCls, then the central metal atom (most electropositive metal, P) is connected with five chlorine atoms and it has 5 coordination number and so on.

In the table below (3), ML\_nE stands for M = central metal atom, L= Ligand or most electronegative element, E= lone pair, n= 2, 3, 4, 5, 6 …). Coordination number 6 has three category of total valence electron i.e. 48, 42, 36 and all have sp^3d^2 hybridization, and similar
phenomenon occurs for other coordination numbers. Here we avoid the use of sp and sp\(^2\) hybridization because they have only single molecular geometry i.e. linear and trigonal.

<table>
<thead>
<tr>
<th>CN 6</th>
<th>TVE</th>
<th>e-pair geometry</th>
<th>Molecular Geometry</th>
<th>CN5</th>
<th>e-pair geometry</th>
<th>TVE</th>
<th>Molecular Geometry</th>
<th>CN4</th>
<th>TVE</th>
<th>Molecular Geometry</th>
<th>e-pair geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML(_6)</td>
<td>48</td>
<td>Octahedral</td>
<td>Octahedral</td>
<td>ML(_5)</td>
<td>Trigonal bipyramidal</td>
<td>40</td>
<td>Trigonal bipyramidal</td>
<td>ML(_4)</td>
<td>32</td>
<td>Tetrahedral</td>
<td>Tetrahedral</td>
</tr>
<tr>
<td>ML(_5)E</td>
<td>42</td>
<td>Octahedral</td>
<td>Square Pyramidal</td>
<td>ML(_4)E</td>
<td>Trigonal bipyramidal</td>
<td>34</td>
<td>See saw</td>
<td>ML(_3)E</td>
<td>26</td>
<td>Tetrahedral</td>
<td>Trigonal bipyramidal</td>
</tr>
<tr>
<td>ML(_3)E(_2)</td>
<td>36</td>
<td>Octahedral</td>
<td>Square Planer</td>
<td>ML(_3)E(_2)</td>
<td>Trigonal bipyramidal</td>
<td>28</td>
<td>T shaped</td>
<td>ML(_2)E(_2)</td>
<td>20</td>
<td>Tetrahedral</td>
<td>Bent/ Angular/ V shaped</td>
</tr>
<tr>
<td>ML(_2)E(_3)</td>
<td></td>
<td></td>
<td></td>
<td>ML(_2)E(_3)</td>
<td>Trigonal bipyramidal</td>
<td>22</td>
<td>Linear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RESULTS AND DISCUSSION**

Now, in order to find out the hybridization and molecular geometry, you only need to remember the above table and it is nothing but subtraction of 8 in column and subtraction of 6 in row. First, we need to calculate all the valence shell electrons in given compound and then the compound must belong to one of the given above number.

*Let us, solve some of the examples:*

**Domain no 6**

**SF\(_6\) (Sulphur hexafluoride)**

Total Valence Electron (TVE) = 6 + 7× 6= 48

Six bond pair (total 12 e-) connected with the six chlorine atoms and all six fluorine contain 36 lone pair electron (6 for each fluorine) i.e. it has no lone pair left in order to complete the total valence electron.
Total bond pair electron = 12
Total lone pair electron = 36 (6 for each six fluorine)
Total valence shell electron= 48
So, hybridization= total bond pair + total lone pair
\[6 + 0 = 5 \text{ i.e. } (sp^3d^2)\]

**Molecular (e⁻ pair geometry) = Octahedral (48)**

Other examples PF₆, SiF₆²⁻:

**SbCl₅²⁻**
Total Valence Electron (TVE) = 5 + 7× 5 +2= 42
Five bond pair (total 10 e⁻) connected with the five chlorine atom and all five chlorine contain 30 lone pair electron (6 for each chlorine) i.e. it has one lone pair left in order to complete the total valence electron.
Total bond pair electron = 10
Total lone pair electron = 30 (6 for each five chlorine)
Total valence shell electron= 40
So, hybridization= total bond pair + total lone pair
\[5 + 1 = 6 \text{ i.e. } (sp^3d^2)\]

**Molecular (e⁻ pair geometry) = Square Pyramidal (40)**

Other examples PF₆, SiF₆²⁻:

**ClF₄⁻**
Total Valence Electron (TVE) = 7 + 7× 4 +1= 36
Four bond pair (total 8 e⁻) connected with the four fluorine atom and all four fluorine contain 24 lone pair electron (6 for each fluorine) i.e. it has two lone pair left in order to complete the total valence electron.
Total bond pair electron = 8
Total lone pair electron = 28 (6 for each four fluorine and 4 for central chlorine atom)
Total valence shell electron= 36
So, hybridization= total bond pair + total lone pair
\[4 + 2 = 6 \text{ i.e. } (sp^3d^2)\]

**Molecular (e⁻ pair geometry) = Square Planar (36)**

Other examples ICl₄⁻, XeF₄
**PCl₅ (Phosphorus pentachloride)**
Total Valence Electron (TVE) = 5 + 7× 5 = 40
Five bond pair (total 10 e-) connected with the five chlorine atom and all five chlorine contain 30 lone pair electron (6 for each five chlorine) i.e. it has no lone pair left in order to complete the total valence electron.
Total bond pair electron = 10
Total lone pair electron = 30 (6 for each five chlorine)
Total valence shell electron= 40
So, hybridization= total bond pair + total lone pair
\[5 + 0 = 5\] i.e. (sp³d)
**Molecular geometry= Trigonal bipyramidal (40)**

**ClF₃ (Chlorine trifluoride)**
Total Valence Electron (TVE) = 7 + 7× 3 = 28
Three bond pair (total 6 e-) connected with the fluorine atom and all three fluorine contain 18 lone pair electron (6 for each fluorine) i.e. it has two lone pair left in order to complete the total valence electron.
Total bond pair electron = 6
Total lone pair electron = 22 (18 at three fluorine and 4 at chlorine)
Total valence shell electron= 28
So, hybridization= total bond pair + total lone pair
\[3 + 2 = 5\] i.e. (sp³d)
**Molecular geometry= T shaped (28)**

**IF₄⁺**
Total Valence Electron (TVE) = 7 + 7× 4 - 1 = 34
Four bond pair (total 8 e-) connected with the fluorine atom and all four fluorine contain 24 lone pair electron (6 for each fluorine) i.e. it has one lone pair left in order to complete the total valence electron.
Total bond pair electron = 8
Total lone pair electron = 26 (22 at four fluorine and 2 at chlorine)
Total valence shell electron= 34
So, hybridization= total bond pair + total lone pair
\[4 + 1 = 5\] i.e. (sp³d)
Molecular geometry = See Saw (34)

Other examples are ICl₃, TCl₄, PCl₅

I₃⁻

Total Valence Electron (TVE) = 7× 3 +1 = 22

Two bond pair (total 4 e⁻) connected with the iodine atom and all two iodine contain 12 lone pair electron (6 for each iodine) i.e. it has six lone pair left in order to complete the total valence electron.

Total bond pair electron = 4

Total lone pair electron = 18 (12 at two corner iodine and 6 at central iodine atom)

Total valence shell electron = 22

So, hybridization = total bond pair + total lone pair

2 + 3 = 5 \( \text{i.e. } (\text{sp}^3\text{d}) \)

Molecular geometry = Linear (22)

Other examples XeF₂, ICl₂⁻

Limitation

1. It has no explanation about the inner and outer d block configuration. No difference create between \( d^2\text{sp}^3 \) and \( \text{sp}^3d^2 \) because it is part of coordination compound where it can be explain accurately.

2. In coordination number four, there are three category (32, 26, 20) but if the TVE is equal to 8 then it is also consider in this domain and then you need to remember the general formula for particular domain.

Domain no 2

NH₃ (Ammonia)

Total Valence Electron (TVE) = 5 + 1× 3 = 8

Three bond pair (total 6 e⁻) connected with the three hydrogen atom and it has one lone pair left in order to complete the total valence electron.

Total bond pair electron = 6

Total lone pair electron = 2 (for nitrogen atom)

Total valence shell electron = 8

So, hybridization = total bond pair + total lone pair

3 + 1 = 4 \( \text{i.e. } (\text{sp}^3) \)

As it has three bond pair and one lone pair then it comes under the category of ML₃E
Molecular (e⁻ pair geometry) = Trigonal pyramidal (8)

Other examples H₃O⁺

H₂O (Water)
Total Valence Electron (TVE) = 6 + 1× 2= 8
Two bond pair (total 4 e⁻) connected with the two hydrogen atom and it has two lone pair left in order to complete the total valence electron.

Total bond pair electron = 4
Total lone pair electron = 4 (for oxygen atom)
Total valence shell electron= 8
So, hybridization= total bond pair + total lone pair
\[ 2 + 2 = 4 \text{ i.e. (sp}^3) \]

As it has three bond pair and one lone pair then it comes under the category of ML₂E₂

Molecular (e⁻ pair geometry) = Bent/ Angular/V shaped (8)

CONCLUSION

Problems (especially multiple-choice questions) can be solved easily, fast and accurately by using this technique. It has great importance in inorganic chemistry, especially coordination chemistry. Most of the problem is solved by using this method and it has some restrictions in CN 4 category of compounds.

REFERENCES
PRACTICES AND CHALLENGES OF IMPLEMENTING LOCALLY AVAILABLE EQUIPMENT FOR TEACHING CHEMISTRY IN PRIMARY SCHOOLS OF NORTH SHEWA ZONE IN AMHARA REGION

Demisachew Shitaw
Debre Birhan College of Teacher Education, Debre Birhan, Ethiopia
Email: ds827319@gmail.com

ABSTRACT
It is in this context that the natural and physical sciences, study and use of environment and local resources has been recognized as one of the basic areas of school curriculum in many developing countries including Ethiopia. Locally available equipment (LAE) offered an alternative solution to do science in classrooms under difficult financial constraints. LAE from locally available materials believed to enrich the capacity to observe, explain and do real chemistry in primary schools and increase the quality of learning. Keeping in view the significance, study in hand is practices and challenges of implementing LAE in teaching chemistry at primary school in North Shewa zone in Amhara Region. The nature of the study is descriptive survey. From 24 woredas 10 of them and from 285 primary schools 130 schools were selected using cluster sampling. From 130 schools all 139 chemistry teachers were including as sample of the study. Data was collected through questionnaire, FGDs, document analysis and observations. It was analyzed by percentage, mean value, t-test and one way ANOVA by SPSS program version 20. Most primary school laboratories of North Shewa Zone are not well equipped with necessary laboratory equipment. That is why; implementing LAE in teaching chemistry is an urgent need everywhere in NSZ at Amhara Region. But the practice of using LAE in the chemistry lesson is poor. But there is a significant difference between teachers taking training on the implementing of LAE and others who didn’t take. There is also a good practice of LAE by teachers working on urban areas when we compare with teachers working at rural areas. The main challenges of implementing LAE in teaching chemistry are lack of skills, interest and knowledge; lack of facilities and awareness problem of school principals. Therefore, giving planned and consecutive training for chemistry teachers and creating awareness for school principals solve the problems of utilizing LAE in teaching chemistry. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

Background of the Study

Practical activities usually require special facilities and equipment. Although fully equipped laboratories and modern equipment are considered essential, it is not necessarily so. It has been argued that conventional laboratory facilities are not needed at the primary level [1]. Purchasing of school science equipment to developing countries has a series of negative side effects. First, foreign exchange is usually in scarce, and the equipment is rather expensive to equip the large number of schools. This results in uneven distribution and partial supply to some schools only [2]. Moreover, spare parts as well as consumable chemicals have to be imported. Besides, the equipment does not suit the existing experiment; it may not be used in the teaching.

One of the approaches to overcome the problems in supply, maintenance and use of equipment for science education is developing equipment from locally available materials. It is possible to design low-cost equipment that are relevant to students and that lead to better understanding [3].

Currently there is also an urgent need everywhere in the world to have low-cost instruments and low-cost experiments for teaching chemistry. As Tilahun, et al [4] indicated, in spite of various efforts, shortage of school laboratory apparatus continues to be a major problem which should be of serious future concern. These necessitate a shift from importing expensive apparatus to a relay on low cost apparatus designed and manufactured by utilizing locally available resources.

In this study the researcher tries to explore how locally available equipment (LAE) is utilized in teaching chemistry, identify the challenges that primary school teachers’ encounter and finally suggest possible solutions in order to improve its practices.
Statement of the Problem

Most of the primary schools are situated in rural areas; they are not able to procure the needed laboratory equipment. In addition to this, primary schools suffer to get adequate funds to purchase equipment. So it is very difficult to fulfill sophisticated scientific equipment to all the school laboratories. Hence, teachers should realize the present situation and they must be encouraged developing LAE. According to Hussain [5], Sileshi [6] and Temechehn [7] designing and production of LAE is relatively easy; and our local community is rich in materials; it is low cost or no cost (1 purchased = 40 locally available equipment) and they are efficient.

Science principles can be taught more effectively only with the use of experimental activities. Real learning takes place only when the students observe the experiment or when they perform the actual experiment. The non-availability of equipment in laboratory highly affects teaching chemistry. As expressed by Umar, etal [8], the use of chalk, black board or explaining the experiment in text books are not the solution to the problem. Therefore, there should be low cost chemistry equipment for the learning of chemistry at primary level.

From the studies mentioned and the researcher’s experience; informal observation while providing training to chemistry teachers at different levels; and providing chemistry courses for in- service trainees in the college made the researcher to doubt the implementation of LAE to realize chemistry concepts using practical work. This initiated him to investigate the teachers practice and challenges of implementing LAE for teaching chemistry.

Having this in mind, the study has the following objectives:

- To explore how LAE is practiced in teaching chemistry.
- To identify if there is any significant difference among different groups on the use of LAE.
- To identify the problems of implementing LAE in teaching chemistry.
• To suggest possible solutions in order to improve its practices in teaching chemistry.

In order to have detailed and comprehensive information, it would have been good if the study takes place throughout Amhara Region; however, to make the study manageable and to complete the study within the time limit, it is restricted to NSZ selected government full cycle primary schools. In addition, it would have been good if the study includes all science subjects at primary schools; however, the researcher’s experience, informal observation while providing training to chemistry teachers at different levels and providing chemistry courses for in-service trainees in the college, it is limited to chemistry subject at grade 7 and 8.

METHODOLOGY

Research Design and Sampling

The purpose of the study is to explore how LAE is utilized in teaching chemistry, to identify the challenges that primary school teachers encounter and finally to suggest possible solutions in order to improve its practices. The study is descriptive survey in nature. This research follows quantitative method. Qualitative method was used to supplement quantitative analysis.

In Amhara Regional State North Shoa Zone there are 24 woredas, of which 10 woredas were selected for study site using cluster sampling. From the total number of 285 schools, 130 schools were taken using cluster sampling in each woreda. Again, from 130 schools having 139 chemistry teachers, all of them were used as sample of the study.

Instruments, Pilot Testing and Validity

In order to assess the practice and challenges of implementing LAE in teaching chemistry at primary schools of NSZ and to answer the basic research questions, the researcher used
questionnaire, document analysis, focus group discussions and observations as means of data collection.

In order to ensure the face and content validity of the questionnaire, draft copies were distributed to different individuals who have better experience in different field of study.

To identify vague and ambiguous items and to modify the shortcomings of the instruments, piloting the instrument was carried out with teachers. After getting valuable comments from the colleagues, pilot study were conducted on 12 (9 males and 3 females) chemistry teachers; they were not part of sample of the study. A total of 3 items were modified after pilot test and the reliability for each group of items were checked by alpha and its reliability test was 0.78.

The data were analyzed using both qualitative and quantitative method. Accordingly, percent, mean, t-test and ANOVA were used for analyzing data collected by questionnaire. Moreover, the responses on observation, document analysis, open-ended items and FGD were organized and analyzed on the basis of common themes in each category of items. The use of qualitative analysis was in supplementing the quantitative data.

RESULTS AND DISCUSSION

Demographic Characteristics of Chemistry Teachers

Table 1 below presents information about respondents characteristics related to sex, qualification, experience and their training exposure.
Table 1: Demographic characteristics of chemistry teachers

<table>
<thead>
<tr>
<th>Categories</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>74</td>
<td>53.2</td>
</tr>
<tr>
<td>Female</td>
<td>65</td>
<td>46.8</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Types of qualification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+2 chemistry diploma</td>
<td>14</td>
<td>10.1</td>
</tr>
<tr>
<td>10+3 three major NS diploma</td>
<td>44</td>
<td>31.7</td>
</tr>
<tr>
<td>10+3 linear chemistry</td>
<td>61</td>
<td>43.9</td>
</tr>
<tr>
<td>10+3 cluster NS diploma</td>
<td>11</td>
<td>7.9</td>
</tr>
<tr>
<td>Others (chemistry degree)</td>
<td>9</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than or equal to 5 years</td>
<td>56</td>
<td>40.3</td>
</tr>
<tr>
<td>6-10 years</td>
<td>43</td>
<td>30.9</td>
</tr>
<tr>
<td>11-15 years</td>
<td>27</td>
<td>19.4</td>
</tr>
<tr>
<td>Above 15 years</td>
<td>13</td>
<td>9.4</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Training on conventional laboratory applications?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>never</td>
<td>46</td>
<td>33.1</td>
</tr>
<tr>
<td>once</td>
<td>40</td>
<td>28.8</td>
</tr>
<tr>
<td>twice</td>
<td>22</td>
<td>15.8</td>
</tr>
<tr>
<td>three times</td>
<td>14</td>
<td>10.1</td>
</tr>
<tr>
<td>more than three</td>
<td>17</td>
<td>12.2</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Training on LAE laboratory applications?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>never</td>
<td>111</td>
<td>79.9</td>
</tr>
<tr>
<td>once</td>
<td>17</td>
<td>12.2</td>
</tr>
<tr>
<td>twice</td>
<td>9</td>
<td>6.5</td>
</tr>
<tr>
<td>three times</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>more than three</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
</tbody>
</table>

These results indicate that LAE didn’t get enough attention by the concerned bodies.

**Background Information about School Laboratory**

In Table 2 we see the general information related to the school and the availability school laboratory.
Table 2: General information about school and school laboratory

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses</th>
<th>F</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of School</td>
<td>urban</td>
<td>63</td>
<td>45.3</td>
</tr>
<tr>
<td></td>
<td>rural</td>
<td>76</td>
<td>54.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Do you have Science (chemistry) laboratory class in your school?</td>
<td>Yes</td>
<td>114</td>
<td>82.0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>25</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Status of school laboratory</td>
<td>Well equipped</td>
<td>6</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Partially equipped</td>
<td>32</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td>Not equipped</td>
<td>76</td>
<td>54.7</td>
</tr>
<tr>
<td></td>
<td>No laboratory room</td>
<td>25</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Why is the school laboratory not equipped?</td>
<td>money problem</td>
<td>60</td>
<td>43.2</td>
</tr>
<tr>
<td>Why don’t you have laboratory room in your school?</td>
<td>market problem</td>
<td>50</td>
<td>36.0</td>
</tr>
<tr>
<td></td>
<td>management problem</td>
<td>20</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td>3</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>Who is responsible, in order to equip your laboratory or in order to have laboratory room in your school?</td>
<td>Government should allocate budget</td>
<td>69</td>
<td>49.6</td>
</tr>
<tr>
<td></td>
<td>NGO should support the school</td>
<td>21</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>Teachers should use LAE</td>
<td>42</td>
<td>30.2</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>7</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Most primary schools in Ethiopia are not equipped and it is very difficult to equip school laboratories due to budget and shortage of equipment in the local market. That is why LAE are very essential for primary school chemistry classes. As can be seen from the last item of Table 2, only 42 (30.2%) of primary school teachers have awareness of LAE and believe preparing and using LAE could solve problems that originated from laboratory facilities.

Practice of practical works for chemistry lesson

Teachers were asked about implementation of practical works for chemistry lesson and their responses are presented in Table 3.
Table 3: Teachers response about implementation of practical works for chemistry lesson

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses</th>
<th>F</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have laboratory (practical) period allocated in your wekly timetable?</td>
<td>Yes</td>
<td>78</td>
<td>56.1</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>61</td>
<td>43.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>How much your locality is rich in LAM?</td>
<td>It is rich in materials.</td>
<td>12</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>It has some materials.</td>
<td>90</td>
<td>64.7</td>
</tr>
<tr>
<td></td>
<td>I could not identify it.</td>
<td>19</td>
<td>13.7</td>
</tr>
<tr>
<td></td>
<td>No material at all</td>
<td>18</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
<tr>
<td>How can you perform different experiments in chemistry lesson?</td>
<td>I thought using lecture method.</td>
<td>61</td>
<td>43.9</td>
</tr>
<tr>
<td></td>
<td>I used demonstration method.</td>
<td>38</td>
<td>27.3</td>
</tr>
<tr>
<td></td>
<td>I jump it.</td>
<td>28</td>
<td>20.1</td>
</tr>
<tr>
<td></td>
<td>I used LAE.</td>
<td>12</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
</tbody>
</table>

In addition to the above result, FGD and observations confirmed that there were serious problems of teaching different concepts of chemistry using practical work.

**Teachers’ utilization level of LAE for teaching chemistry**

Analyses of teachers’ responses were made using percentage and mean. Teachers rated a five point likert scale for utilization level of LAE: always =5; frequently=4; occasionally=3; rarely=2; never=1; for challenges of implementing LAE: strongly agree = 5; agree = 4; undecided = 3; disagree = 2; and strongly disagree = 1. Regarding the items, for the purpose of this study, mean from 2.50 – 3.49 range was taken as moderate level, while from 3.50 and above was considered as high level participation in the statement and mean of less than 2.50 was considered to indicate low level of participation in the statement.
Table 4: Teachers response on utilization of LAE for teaching chemistry

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Response</th>
<th>Mean F (%)</th>
<th>Rarely F (%)</th>
<th>Occasionally F (%)</th>
<th>Frequently F (%)</th>
<th>Always F (%)</th>
<th>St.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How often you use locally available apparatuses for teaching chemistry?</td>
<td>Never: 25(18)</td>
<td>50(36)</td>
<td>44(31.7)</td>
<td>18(12.9)</td>
<td>2(1.4)</td>
<td>2.01</td>
<td>0.979</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rarely: 33(23.7)</td>
<td>43(30.9)</td>
<td>43(30.9)</td>
<td>18(12.9)</td>
<td>2(1.4)</td>
<td>1.98</td>
<td>1.031</td>
</tr>
<tr>
<td>2</td>
<td>How often you use locally available chemicals for teaching chemistry?</td>
<td>Occasionally: 35(25.2)</td>
<td>55(39.6)</td>
<td>38(27.3)</td>
<td>9(6.5)</td>
<td>2(1.4)</td>
<td>1.35</td>
<td>0.939</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequently: 30(21.6)</td>
<td>36(25.9)</td>
<td>44(31.7)</td>
<td>22(15.8)</td>
<td>7(5.0)</td>
<td>2.25</td>
<td>1.142</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Always: 35(25.2)</td>
<td>55(39.6)</td>
<td>38(27.3)</td>
<td>9(6.5)</td>
<td>2(1.4)</td>
<td>1.35</td>
<td>1.183</td>
</tr>
<tr>
<td>3</td>
<td>Do you prepare plan to use LAE for chemistry lesson?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Do you motivate your students to use LAE for their practical work?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do you read and ask questions to refresh your knowledge about LAE?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Do you discuss with your colleague to prepare LAE?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Do you share ideas about LAE with your colleagues during department or cluster schools meeting?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>248(25.5)</td>
<td>310(31.9)</td>
<td>287(31.3)</td>
<td>133(29.5)</td>
<td>26(2.7)</td>
<td>1.81</td>
<td>1.076</td>
</tr>
</tbody>
</table>

Note: F = frequency, % = percentage and St.D = standard deviation

This shows that significant number of chemistry teachers did not use LAE for teaching chemistry. Similarly, data collected by FGD, document analysis and from the observation of schools laboratory almost all school did not have laboratory plan to use LAE. In some schools, the researcher observed very few numbers of low-cost apparatuses prepared by teachers.

The practice of LAE among different groups

Table 5: Independent Sample t-test values of implementing LAE by sex and place of school

<table>
<thead>
<tr>
<th>Items</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>74</td>
<td>15.4750</td>
<td>4.76797</td>
<td>-0.556</td>
<td>137</td>
<td>0.579</td>
</tr>
<tr>
<td>Female</td>
<td>65</td>
<td>16.0000</td>
<td>6.36532</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place of work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>63</td>
<td>18.1515</td>
<td>5.38587</td>
<td>3.027</td>
<td>137</td>
<td>0.003</td>
</tr>
<tr>
<td>Rural</td>
<td>76</td>
<td>14.9340</td>
<td>5.31533</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Independent sample t-test was used to examine the difference between male and female chemistry teachers on their implementation of LAE. It was found that there were no significant
statistical differences between male and female teachers (p>0.05) but there was a statistical
significant difference between town and rural school chemistry teachers on their implementation
of LAE (p<0.05) as shown in Table 5.

Table 6: One way ANOVA values of implementing LAE by experience and qualification

<table>
<thead>
<tr>
<th>Items</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 5 years</td>
<td>56</td>
<td>13.9630</td>
<td>5.7678 3</td>
<td>3</td>
<td>43.274</td>
<td>1.451</td>
<td>0.231</td>
</tr>
<tr>
<td>6 -10 years</td>
<td>43</td>
<td>15.6607</td>
<td>5.5244 1</td>
<td>1</td>
<td>11.101</td>
<td>0.700</td>
<td>0.630</td>
</tr>
<tr>
<td>11-15 years</td>
<td>27</td>
<td>16.3953</td>
<td>5.3280 0</td>
<td>0</td>
<td>4.676</td>
<td>0.247</td>
<td>0.831</td>
</tr>
<tr>
<td>&gt;15 years</td>
<td>13</td>
<td>17.1538</td>
<td>4.9133 5</td>
<td>5</td>
<td>24.529</td>
<td>4.437</td>
<td>0.052</td>
</tr>
<tr>
<td>Qualification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+2 chemistry diploma</td>
<td>14</td>
<td>18.5000</td>
<td>4.4347 1</td>
<td>1</td>
<td>83.939</td>
<td>2.945</td>
<td>0.023</td>
</tr>
<tr>
<td>Others (chemistry degree)</td>
<td>9</td>
<td>17.8000</td>
<td>5.9329 6</td>
<td>6</td>
<td>30.792</td>
<td>1.440</td>
<td>0.154</td>
</tr>
<tr>
<td>10+3 three major diploma</td>
<td>44</td>
<td>17.5000</td>
<td>5.1195 0</td>
<td>0</td>
<td>23.641</td>
<td>1.239</td>
<td>0.273</td>
</tr>
<tr>
<td>10+3 linear chemistry diploma</td>
<td>61</td>
<td>14.5765</td>
<td>5.4475 3</td>
<td>3</td>
<td>16.235</td>
<td>0.878</td>
<td>0.426</td>
</tr>
<tr>
<td>10+3 cluster diploma</td>
<td>11</td>
<td>10.0000</td>
<td>3.8773 4</td>
<td>4</td>
<td>8.924</td>
<td>1.451</td>
<td>0.196</td>
</tr>
</tbody>
</table>

As indicated in Table 6, implementation of LAE based on experience, the value of significant level
is greater than 0.05. It shows that there is no significant difference among chemistry teachers in
their experience. But implementation of LAE based on qualification has significant difference
(p<0.05). Concerning qualification, pre-service training has its own impact in implementing LAE.
Table 7: One-way ANOVA values of implementing LAE based on training experience

<table>
<thead>
<tr>
<th>Items</th>
<th>N</th>
<th>Mean</th>
<th>Std. D.</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training on LCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>never</td>
<td>111</td>
<td>14.6757</td>
<td>5.00393</td>
<td>3</td>
<td>207.652</td>
<td>7.936</td>
<td>0.000</td>
</tr>
<tr>
<td>once</td>
<td>17</td>
<td>18.7059</td>
<td>5.88180</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>twice</td>
<td>9</td>
<td>21.3333</td>
<td>5.00000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>three times</td>
<td>2</td>
<td>21.5000</td>
<td>4.94975</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; three</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training on conventional lab. work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>never</td>
<td>46</td>
<td>15.5152</td>
<td>4.87456</td>
<td>4</td>
<td>100.767</td>
<td>3.599</td>
<td>0.008</td>
</tr>
<tr>
<td>once</td>
<td>40</td>
<td>14.2000</td>
<td>5.50617</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>twice</td>
<td>22</td>
<td>16.5000</td>
<td>6.26973</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>three times</td>
<td>14</td>
<td>18.5000</td>
<td>2.51661</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; three</td>
<td>17</td>
<td>21.8571</td>
<td>5.49025</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 7, implementing LAE based on training on LAE has significant difference (p<0.05). Post Hoc comparison using Tukey HSD test indicated that the mean scores for teachers participating training on LAE twice and three times have significant difference from others.

Similarly, conventional laboratory practice training has also statistically significant difference (p<0.05) as shown in Table 7. Post Hoc comparison using Tukey HSD test indicated that the mean scores for teachers participating conventional laboratory training more than three times has significant difference from others. This helps to infer that chemistry teachers participating on LAE training performed better than teachers participating on conventional laboratory training in the implementation of LAE on their chemistry class.

**Challenges of implementing LCE for teaching chemistry**

The chemistry teachers also expressed their views about the challenges in implementing LAE in primary schools. The results are presented in Table 8 below.
Table 8: Teachers’ response on challenges in implementing LAE in primary schools

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Response</th>
<th>Mean</th>
<th>St.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Uncertain</td>
</tr>
<tr>
<td>1</td>
<td>You have awareness to use LAE for chemistry class?</td>
<td>20 (14.4%)</td>
<td>24 (17.3%)</td>
<td>47 (33.8%)</td>
</tr>
<tr>
<td>2</td>
<td>You know how to use LAE to teach chemistry.</td>
<td>20 (14.4%)</td>
<td>25 (18%)</td>
<td>39 (28.1%)</td>
</tr>
<tr>
<td>3</td>
<td>You know how you replace commercially prepared apparatus with locally prepared apparatus.</td>
<td>10 (7.2%)</td>
<td>41 (29.5%)</td>
<td>47 (33.8%)</td>
</tr>
<tr>
<td>4</td>
<td>You know how you replace commercially prepared chemicals with locally prepared chemicals.</td>
<td>25 (18%)</td>
<td>22 (15.8%)</td>
<td>42 (30.2%)</td>
</tr>
<tr>
<td>5</td>
<td>You have enough knowledge on application of LAE in chemistry lesson.</td>
<td>11 (7.9%)</td>
<td>25 (18%)</td>
<td>44 (31.7%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>86 (12.4%)</td>
<td>137 (19.7%)</td>
<td>219 (31.5%)</td>
</tr>
<tr>
<td></td>
<td>Concerning Skills challenges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>You have skill to construct LAE to teach chemistry.</td>
<td>17 (12.2%)</td>
<td>35 (25.2%)</td>
<td>41 (29.5%)</td>
</tr>
<tr>
<td>7</td>
<td>You have skill to prepare LAE from LAM for chemistry class.</td>
<td>16 (11.5%)</td>
<td>33 (23.7%)</td>
<td>34 (24.5%)</td>
</tr>
<tr>
<td>8</td>
<td>You could replace traditional lab apparatus by LAE for effective practical work.</td>
<td>8 (5.8%)</td>
<td>40 (28.8%)</td>
<td>51 (36.7%)</td>
</tr>
<tr>
<td>9</td>
<td>You don’t have any problem to choose LAE for teaching chemistry.</td>
<td>9 (6.5%)</td>
<td>54 (38.8%)</td>
<td>37 (26.6%)</td>
</tr>
<tr>
<td>10</td>
<td>You have skill to use LAE for teaching chemistry effectively.</td>
<td>9 (6.5%)</td>
<td>35 (25.2%)</td>
<td>43 (30.9%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>59 (8.5%)</td>
<td>197 (28.3%)</td>
<td>206 (29.6%)</td>
</tr>
<tr>
<td></td>
<td>Concerning Attitude challenges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>You are interested to use LAE for teaching chemistry.</td>
<td>23 (16.5%)</td>
<td>24 (17.3%)</td>
<td>38 (27.3%)</td>
</tr>
<tr>
<td>12</td>
<td>LAE are efficient to teach chemistry at primary school.</td>
<td>31 (22.3%)</td>
<td>30 (21.6%)</td>
<td>30 (21.6%)</td>
</tr>
<tr>
<td>13</td>
<td>Replacing traditional lab equipments by LAE is relevant to your own situation.</td>
<td>21 (15.1%)</td>
<td>28 (20.1%)</td>
<td>44 (31.7%)</td>
</tr>
<tr>
<td>14</td>
<td>You are committed to teach chemistry using LAE.</td>
<td>20 (14.4%)</td>
<td>35 (25.2%)</td>
<td>35 (25.2%)</td>
</tr>
<tr>
<td>15</td>
<td>Teaching load is not a factor in order to construct and use LAE.</td>
<td>9 (6.5%)</td>
<td>42 (30.2%)</td>
<td>42 (30.2%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>104 (15%)</td>
<td>159 (22.9%)</td>
<td>189 (27.2%)</td>
</tr>
</tbody>
</table>
The challenges of implementing LAE were challenges of knowledge, skill and attitude and their mean values are 2.18, 1.86 and 2.06, respectively. These challenges are also observed during observations and document analysis.

CONCLUSIONS

Based on major findings, the following conclusions were drown:

- Most primary school laboratories of North Shewa Zone are not well equipped with necessary laboratory equipment. That is why; implementing LAE in teaching chemistry is an urgent need everywhere in Amhara region at Ethiopia.

- Even if, the practice of using LAE in chemistry lesson in those primary schools is poor, there is a good practice of using LAE by 12+2 diploma chemistry teachers, 10+3 three major diploma teachers and degree graduate chemistry teachers. Moreover, a significant difference between teachers who took training on the implementing of LAE and others did not was observed. In addition, there is also a good practice of LAE by teachers working on urban areas when we compare with teachers working at rural areas.

- The main challenges of implementing LAE in teaching chemistry are lack of skills, interest and knowledge; lack of facilities and awareness problem of school principals. Therefore, giving planned and consecutive training for chemistry teachers and creating awareness for school principals solve the problems of utilizing LAE in teaching chemistry.

REFERENCES


ACKNOWLEDGMENTS
I would like to thank Mr. Yared Fantahune, Mr. Asefa Demissie, Mr. Gebeyehu Yismaw, Mr. Ashenafi Tadesse and Mr. Semachew Tafere. I am also grateful to my college, Debre Birhan CTE, for financing the study.
CONTEXTUALIZATION AND INTERDISCIPLINARITY IN CHEMISTRY TEACHING IN BRAZIL: AFTER TWO DECADES, EVERYBODY KNOWS BUT NOBODY UNDERSTANDS

Hoziam H.X. Rocha, a Deyse de S. Dantasb and Robson Fernandes de Farias

a. Universidade Federal do Rio Grande do Norte. Cx. Postal 1664, 59078-970, Natal-RN, Brasil. *E-mail: robdefarias@yahoo.com.br
b. Universidade Federal do Amapá, 68903-419, Macapá-AP, Brasil.

ABSTRACT

In Brazil, a new law dedicated to the establishment of the policy and bases of national education (law 9.394/1996) was published in 1996. Then with the publication, in 1999, of the National Curricular Parameters for High School Teaching in Brazil, modifications in the chemistry teaching that should be promoted by a contextualized and interdisciplinary teaching were proposed. Based on textbook analysis and interviews with high school teachers, the present study argues that the proposed modifications were not achieved, taking into account that both, chemistry teachers practices and chemistry high school textbooks, have not changed in two decades. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

In Brazil, since 1996, with the publication of a new law dedicated to the establishment of the policy and bases of national education (law 9.394/1996) and specially with the publication, in 1999, of the National Curricular Parameters for High School Teaching, two words have been leading a series of actions in high school (and also in the undergraduate courses, dedicated to the formation of the new generations of elementary and high school teachers) teaching in Brazil: contextualization and interdisciplinarity.

In a broad sense, contextualization means that the teaching of a given knowledge must be inserted in a context, that is, must be putted in a large understanding of that knowledge, in order to not make of the student a narrow-minded person. Also in a broad sense, interdisciplinarity means to correlate the specific knowledge of all sciences to show that, for example, chemistry, physics and biology are not “isolated” sciences, but that their specific subjects and achievements are closely related.

It is understood that contextualization is a process of embedding knowledge in history, culture, philosophical questions, and personal experiences, and it is the prototypical mode for generating knowledge in the humanities [1].

So, not only the background provided for future teachers in the undergraduate courses, but also the textbooks and the practice of high school teachers have been (presumably) redirected, taking into account the two previously mentioned words.

In the present work it is reported a research involving both, analysis of high school chemistry textbooks and interviews with high school teachers in order to evaluate if, after two decades, some real change can be verified in the teaching of chemistry in the high schools.
METHODOLOGY

Twelve high school chemistry textbooks (from the main authors, employed for the most schools, both public and private) were analyzed. These books are used in Brazil, in all States. Twenty high school teachers, that had concluded their graduations in the 1991-2007 years were interviewed. So, as can be verified, were chose teachers that have been formed before and after the edition of the law 9.394/1996.

The teachers were chosen taking into account their experience as teachers, ranging from those with a few years as teachers (5-6 years of experience) to those with many years of professional activity (12-21 years as teachers). As will be verified in the results and discussion section, this was a suitable choice, since there is remarkable differences in the teachers’ practices in the classroom, depending on their experiences.

The interview consisted of mainly a questionnaire with some key questions to be answered in a “yes” or “no” style, in order to avoid extremely “open” responses with no real meaning. The research was conducted in Rio Grande do Norte State, Brazil.

RESULTS AND DISCUSSIONS

Analyzing the chemistry high school textbooks after two decades of the law (after the edition of the law 9.394/1996), it is possible to verify that no “real” modifications were introduced. In Brazil, chemistry textbooks dedicated to high school teaching published in the 2010’s are not different from those published in the 1990’s, 1980’s or 1970’s. The only changes that can be observed are in the graphical aspects. For example, a 1970’s textbook only talk about alcohols, whereas a 2010’s textbook brings with the text a colorful photo of an ethanol bottle.
The topics and sequence of the subjects, as well as the teaching approaches, however, remains the same. So, no real innovations were observed in high school textbooks, after analysis of twelve of the most employed ones [2].

Furthermore, in the high school classes, the practice of the chemistry teacher, in the public or private schools, also remains the same. From the interview and questionnaires it was verified that 70% of the teachers declared that contextualize and put the chemistry knowledge in an interdisciplinary fashion could improve the chemistry learning by high school students. However, only 25% of them have studied the National Curricular Parameters for High School Teaching, and most of them have difficulties in defining contextualization and interdisciplinarity. In other words: chemistry teachers in the high school do not understands clearly what really means contextualization and interdisciplinarity [1, 2].

The same teachers (75 %) said that their perception in that other teachers (physicists, biologists, for example) do not try to teach taking into account contextualization and interdisciplinarity goals. They also stated (85 %) that the lack of interaction with the teachers of other areas, the lack of appropriate pedagogical resources and the reduced time (number of hours, per week, dedicated to chemistry in the high school) compromise the achievement of such goals. Furthermore, only 60% of the teachers declared that they try to teach in a contextualized and interdisciplinary fashion.

In the teachers’ opinion (70%), the high school chemistry textbooks present the subjects in a contextualized and interdisciplinary fashion. Such results are in contrast with the perception of the authors of the present work, as mentioned in the first paragraph.
The data shown until now take into account the total population of interviewed teachers. However, comparing teachers educated in the years 1991-1998 (T1), with those educated in the years 2000-2007 (T2), some remarkable differences are observed:

a. Can teaching chemistry in a contextualized and interdisciplinary fashion improve the learning process? T1 = 37.5%; T2 = 91.7%;

b. Have you already had ready/study the National Curricular Parameters? T1 = 0.0%; T2 = 41.7%;

c. In your classes, have you ever been concerned to teach chemistry in a contextualized and interdisciplinary fashion? T1 = 12.5%; T2 = 58.3%;

d. When you were an undergraduate student (had been trained as a teacher) in the pedagogical disciplines, were contextualization and interdisciplinarity main themes? T1 = 0.0%; T2 = 25.0%. So, even to the teachers trained after the edition of the law 9.394/1996, contextualization and interdisciplinarity were not properly focused in the university courses;

e. Do you have some interest in postgraduate courses dedicated to the contextualization and interdisciplinarity themes? T1 = 25.0%; T2 = 91.7%

CONCLUSIONS

As general conclusions, it can be stated that, after two decades, no “real” modifications can be observed in the high school chemistry textbooks.

Concerning the teachers education and practices, despite the fact that “younger” teachers are most involved (at a theoretical and informational level, at least) with the contextualization and interdisciplinarity themes, it can be verified that even they do not have proper perception/understanding of such themes.
It can also be verified that the “revolution” in chemistry teaching expected after the publication of the National Curricular Parameters for High School Teaching was, in the first moment, a promise, then a mirage, and nowadays it is a deception. Not only because of this but also it is important to remember that in 2012, Brazil was in the 59th place (in a total of 65 countries) in the PISA (Programme for International Student Assessment) evaluation of science learning, promoted by OCDE (Organisation de coopération et de développement économiques) (considering fifteen years old students). The results of the 2015 test was be published in December 2016 but no significant modifications are expected. In the PISA science exam [3], 55.3% of the Brazilian students achieved only the level 1 of knowledge, that is, they are able to apply their scientific knowledge to a few day by day situations and to provide correct scientific explanations to a few facts based on their evidences. So, the PISA exam results shows, more clearly than any other data, that the main goals proposed by the so called contextualization and interdisciplinarity, were not achieved.

At this moment, it is not possible to know if the future of chemistry teaching-learning in Brazil will be a promise, a mirage or a disappointment.

REFERENCES
UNTANGLING CHEMICAL KINETICS THROUGH TANGIBLE AND VISUAL REPRESENTATION OF MATTER

C. G. Kerstiensa, D. C. Sisniegab, A. Gomez, B. M. Gunna, J. E. Becvara, and M. Narayana,†
Department of Chemistry, University of Texas at El Paso, United States
Email: mnarayan@utep.edu

ABSTRACT
Second semester General Chemistry students are introduced to Chemical Kinetics as part of their curriculum. Often, instructors require that students plot Concentration vs. Time graphs for elementary chemical reactions as part of the learning process. Despite employing graphical tools, students often find it difficult to conceptualize conservation of mass (matter) under constant volume conditions and thus, are unable to accurately depict concentration changes that occur during chemical reactions. We propose that the use of elementary shapes (e.g. triangles, circles, squares) to represent different atoms in molecules facilitates the comprehension of chemical kinetics. Specifically, generation of “Concentration vs. Time” graphs rendered with the aid of tangible and/or pictorial representations of atoms using fixed numbers of distinct and representative shapes helps students visualize and track the conversion of reactant “R” into product “P” as a function of time. Importantly, it also helps understand that reaction processes “start” and “end” with the same number of atoms as the reaction progresses from reactants to products. Through such a proposed visual and/or tangible tool, students can visualize which compound is the limiting reagent; how much of the other reactant is “left over”; and how much product can be made. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

Chemical kinetics is the study of the rates of chemical processes [1-3]. The reaction rate is defined as the change in the concentrations of a reactant or a product as a function of time (M/s) [4]. A second and noteworthy aspect of chemical kinetics as taught in General Chemistry 2 is that the reaction proceeds to completion. The reaction stops when one or more reactants are completely consumed. If one reactant is consumed before the consumption of other participating reactants, that reactant is called the “limiting reagent”. The limiting reagent determines the quantity of product that can be made [4].

In the simplest case in which a single reactant (R) converts to a unique product (P), the reaction is often represented as “R → P” [4]. Here, R automatically qualifies as the limiting reagent to form P. While it is not possible to determine the rate of this reaction without more details, we can state how the rates of R and P relate to each other. Rate is equal to the change in concentration over time or Rate = \( \frac{\Delta M}{t} \). In this case, for every one molar reactant lost there is a gain of one molar concentration of product. This can be shown as Rate = \( \frac{-\Delta [R]}{t} = \frac{\Delta [P]}{t} \) for this reaction [4].

For the reaction R → 2P, for every one molar (1M) concentration of R lost, there is a gain of two molar P. This implies that the rate of consumption of the reactants is only half as rapid, relative to the rate of appearance of the products. The overall reaction rate is represented as rate = \( \frac{-\Delta [R]}{t} = \frac{1}{2} (\Delta [P]/t) \). For the reaction type, 2R → P, the equality would be the reverse of the aforementioned scenario. This is because two molar reactants are being consumed for every one molar product produced. Therefore, the rates would relate as \( \frac{-\Delta [R]}{t} = \Delta [P]/t \).
Concentration vs. Time

A typical pictorial representation of the relation between reaction rates of reactants and their products involves the use of a concentration vs. time graph. For example, General Chemistry textbooks provide a graphical representation of reaction progress as shown in Figure 1. The molecules versus time graph is representative of reaction progress in the reaction type A → B. Since the reaction stoichiometry is 1:1, the rates of reactant consumption and product production are equal. Inspection of the curve reveals that as the reaction proceeds to completion, the rate of the reaction decreases. While the precise rate of the reaction may not be easily inferred from the graph, it can be determined that the rate of reactant consumption equals the rate of which products are formed (both rates represented in “molecules” per second). While this graph depicts reaction progress as a function of “molecules” consumed and produced, the data can be suitably transformed to obtain a concentration versus time graph.
METHODOLOGY/EXPERIMENTATION

The Tangible and Visual Model (Instillation in a “Peer-Lead Workshop”)

Even though the (above) material is well articulated in the textbook and in the classroom, students are often unable to construct concentration versus time graphs correctly [5]. One contributing factor could be the students’ difficulty in conceptualizing conservation of mass under constant volume. In Peer-Lead Team-Learning Workshops, students would generate curves that would create end results with surplus or deficit concentrations of reactants and/or products [6, 7]. This is particularly true with respect to non 1:1 stoichiometric reactions. Typical student generated curves are shown in Figure 2. Frequently, the rendered plots have amounts of concentration spontaneously and incorrectly appear or disappear (Top and bottom left).

If students are unable to create the graphs correctly or comprehend the reaction quantitatively, then they are unable to answer related questions regarding the limiting reagent, leftover reagent(s), or the amounts of product(s) produced.

It is therefore essential for students to understand what a reaction equation is stating. A number of techniques involving the use of objects and blocks to understand chemical kinetics, equilibrium, and stoichiometry have been previously described in an effort to help General Chemistry students assimilate material related to kinetics and equilibrium [8-20]. Yet, a gap exits in the application of tools that relate stoichiometry, the consumption of reactant, generation of product, and their representation using graphs, to aid in the comprehension of chemical kinetics.
We propose that the application of an integrative tool involving visual and tactile responses to translate reaction progress to a graph significantly facilitates comprehension of chemical kinetics. We also suggest that such a tool is even more effective when implemented in peer-led team learning workshops. Note that in the workshop model, students practice and apply what they have learned in lectures with facilitation from a peer leader.

Consider the reaction represented in Figure 3. The reaction is of the type $2A + 3B \rightarrow 1C$. While it should be evident that it takes two moles of A and three moles of B to make one mole of C, the use of rectangles and circles to represent the reactants promotes comprehension of the stoichiometry. During the course of the reaction, the geometric shapes help make evident that no matter has been destroyed; rather, it has chemically reacted (“rearranged” or transformed) to form a new compound (utilizing all available circles and rectangles as dictated by the stoichiometry).

For reactions with more complicated compounds, we may need to visualize every element involved. For example, when aluminum trioxide decomposes to form aluminum and oxygen, represented by squares and circles, respectively (Figure 4), if we look at both sides of the reaction (reactants and products) we can infer that there exist equal amounts (concentrations) of oxygen and aluminum. This reinforces the fact that there is no new creation or elimination of matter, but just a rearrangement into products.
Application

Sample problem: 6 M of sulfur dioxide and 6 M of oxygen react to form sulfur trioxide. State how much product can be made, identify the limiting reagent, and how much of the other reagent is left over. Also draw a concentration versus time graph.

Step 1. Write down the balanced reaction (Figure 5).

Step 2. Choose the shapes of your elements. In this case, we depict squares for sulfur atoms and circles for oxygen atoms.

Step 3. “Draw the amount of molarity” you have where each compound you draw represents one molar concentration.

Step 4. Complete the reaction one time, and show the used reactants and how much product is produced. Figure 6.

Step 5. Repeat step 4 until you run out of a reactant. Be aware that the reactant which runs out first is the limiting reagent.

Step 6. Enclose in a box any reactant leftover and the entire product created at the end of the reaction.
Step 7. Begin to draw the graph by labeling the axis as shown in Figure 7.

Step 8. Label the y-axis where your reactants and product begin (Note: We had no product in the beginning).

Step 9. Show the changes in concentration of each compound from the first time you completed step 4 by placing dots on the graph at a time.

Step 10. Repeat for each time you completed step 4. Keep in mind to increase the gap between the times it took to reach those concentrations, because as stated before, the rate of reaction continues to slow down as the reaction moves towards completion.

Step 11. Connect the dots to form a curved line for each different compound.

Step 12. Label the final concentration of each compound as shown in Figure 8.

CONCLUSIONS

By plotting accurate graphical representations of reaction progress, the students can visualize how the rates of appearance and disappearance of each compound relate to each other at any given point along the reaction. They can also become cognizant of the fact that matter is conserved throughout the course of the reaction.
In the Workshop, Peer Leaders can provide students with more practice problems to help reinforce the understanding of chemical kinetics and the relationship between rates by: a) changing concentrations, b) adding product at the beginning of the reaction, c) asking students to change the concentration so that no reactant is present at the end of a multi-reactant reaction, and d) querying what is present at the half-time of the reaction [20].

An enhancement that can be made to the activity is to use building blocks or molecular kits to represent the compounds. By doing this, the students are able to physically “disassemble the reactants” and create products (Figure 9).

Review of previous material and preparation of future material

By completing the above activity students are able to review material previously learned in general Chemistry 1, which includes balancing equations, stoichiometry, and concentration. They are also able to review molecular geometry and hybridization material if molecular kits or Lewis structures are included. By helping them understand the conservation of mass and reaction rates, students are better prepared for future material in equilibrium and Organic Chemistry.

REFERENCES AND NOTES

ACKNOWLEDGEMENTS
Bonnie Valdez
Peer Lead Team Learning International Society
EVALUATING THE IMPACT AND POTENTIAL OF THE CHEMICAL SCIENCES IN CATALYSING THE ECONOMIC DEVELOPMENT THROUGH POTENTIAL CHEMICAL ENTREPRENEURSHIP IN LESOTHO

Mosotho J. George1,* and Thembi Setubatuba1

1 Department of Chemistry and Chemical Technology, National University of Lesotho, P.O. Roma 180, Lesotho – Southern Africa. Tel.: +266 5221 3502, Fax: +266 2234 0000.

* Corresponding author: jm.george@nul.ls or maluti2005@gmail.com

ABSTRACT
Science is central for research and innovation that are key drivers for economic development. However, with the never improving capital investment towards higher education in most African countries, the level of infrastructure in the universities hinders adequate training of human resources and the economic development emanating from science and technology innovation. This paper shares the history, impact and the prospects of the chemical sciences program at the National University of Lesotho in transforming the local economy through translation of science with emphasis on potential commercialization and entrepreneurship in partnership with local entities: cooperatives, community-based organization or private small-medium enterprises other than the few present and somewhat unwilling companies. Finally we recommend the coordination of the innovation and incubation initiatives in public sector to partner with the universities as centres of knowledge creation. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

The role of higher education institutions (HEIs) has continued to be a subject of debates recently with the expansion of the mandate from purely centres of teaching and learning through to research, incubation and support of small business but also in offering of consultancy services to small and medium enterprises as well as ordinary citizenry. This mandate has even gone further in that HEIs are also expected to participate in broad national issues of relevance to not only higher education but societal issues at large [1]. This is more so in the public universities where funding is mainly sourced through government subvention. With the consistent and “chronic” decline in governments’ subvention [2, 3], there are views that most public universities could face some form of extinction [4]; unless they undergo some kind of restructuring or they claim their political power – perform their duties and impart positive influence to their graduates to excel in using the skills they have developed during the training [5].

Relevance is often a thorny issue owing to mainly poor employment opportunities in the country where it becomes easier for the markets to blame the universities for poor relevance while this issue could be a consequence of low or poor absorptivity of the markets to the graduates other than the inability of the graduates to perform the tasks employed to perform [6], as well as inaccessible credit for entrepreneurial capital frustrating the entrepreneurial initiatives, rather than the issue of relevance as it will become apparent in this article. However, since this is not the subject of this paper, it will not be discussed further than it has already.

For higher education to be effective, multi-party partnerships between academia and private/public sectors are touted as a golden bullet enabling academic research to translate into tangible programs and policy resulting in a widely published triple helix model [7, 8]. Partnerships are believed to be responsible for the birth of new companies [9], as well being able to afford the
spread and wider access of resources. For example, private sector is able to access resources at HEIs while HEIs also access the financial resources from the private sector. The triple helix model is believed to enable development of a knowledge-based economy.

**SETTING UP THE SCENE**

Lesotho – a tiny wholly landlocked country within South Africa has only one university offering natural (basic) sciences – National University of Lesotho. This university establishment dates back in 1945 when it was started as Pius XII college, then underwent several metamorphoses to become UBBS, later UBLS and subsequently the present day NUL in 1975 together with its siblings UB and UNISWA that descended from the same ancestry Pius XII – UBLS [10]. This university, and its predecessors, has produced a number of renowned alumni that graced the Southern African region especially during the racial segregation in South Africa.

However, despite its rich history, this once a giant seems to be falling asleep due to consistent and sturdy downward spiral of disposable revenue due to the declining subvention from the government (see Figure 1) that is a sole financier [11].

![Figure 1: A glimpse of the National University of Lesotho subvention and personnel expenditure 2003 – 2013](image)
The observed improvement in the deficit in 2011-2012 was when the University experienced the highest staff loss in its history [12]. This decline in financial resources frustrates the teaching and learning of sciences more than any other disciplines [13]. Besides the reality of dwindling resources, this institution is confronted with yet another challenge of receiving brutal and unwarranted negative publicity in local media for being unable to respond to the national challenges [14, 15], some going as far as labelling it a “glorified high school” [16].

While there is no consensus about the reasons for the declining subvention, arguments point to different issues depending on who make them. These arguments include lack of patriotism by the rulers/political authority, unruly behaviour/insubordination of academics at the institution towards the political authorities, deterioration of the standards at NUL as has been pointed out earlier, just to mention but a few. However these arguments point more towards issues of governance rather than the relevance of the institution’s programs. Amongst the plethora of articles, editorials and columns published in local media about the institution, only one was identified that suggested the financial plight of the institution as one of the main reasons why the institution cannot do as well as it should [17]. The author’s arguments were in tandem with those expressed elsewhere that the performance of a university and its international ranking thereof is dependent on the funding and availability of functional infrastructure [18, 19]. As a result, there have been a number of initiatives aimed at transforming/restructuring the university, some arising from the wisdom of the institution’s management, some were a result of direct instruction from the political authority while others are simply in response to the financial difficulties.

Perhaps before getting into the thesis of this manuscript, it is worth appraising the global trends in science and technology. As the manuscript is centered on the chemical sciences, the authors delved more into the chemical sciences notwithstanding the importance of the other
sciences and/or programs. Traditionally, the Faculty of Science had been offering basic sciences in a double major and/or major-minor combinations arguably for the purposes of 1) providing a foundation for professional qualifications such as medicine and engineering, 2) knowledge creation and science education as well as 3) enabling the graduates to take up graduate studies. However, in the period 1990 to 2000, the term technology started to trend globally as technology was touted as a means through which nations could free themselves from economic bondage. Consequently, in order to align itself with the then contemporary trend, the University through the Faculty of Science, as the main custodian of science and technology development, advised itself to introduce technology programs, and as a consequence the Faculty metamorphosed into the Faculty of Science and Technology. Thereafter the academic departments followed suit giving rise to the current Department of Chemistry and Chemical Technology which is a subject of this report. While this Department, like its sister departments used to offer the traditional double major, or major-minor combinations, as mentioned earlier, it later introduced the Chemical Technology programme and its name also changed to Department of Chemistry and Chemical Technology in order to inspire hope and confidence in its prospective clientele, students and the local community.

Among the courses taken in this program is an industrial internship where students are expected to spend 6 months working closely with the industry learning about the industry operations as well as carrying out a practical research to address some of the challenges faced by the industry/company they are engaged in. Due to the close interaction with the private sector it was hoped that this program could be more relevant to the market needs as well as contributing more towards the transformation of the economic landscape of the country owing to the many applications of chemical sciences: manufacturing, engineering and analytical sciences. While this internship provides a learning experience to the students, it also affords easy labor to the companies
concerned, while it provides those companies a chance of identifying candidates with the right skills, aptitude and attitude hence saves such companies the time and expense involved in the recruitment processes to fill any prospective vacancies [6].

Despite the anticipated potential of the program and the enthusiasm demonstrated by the private sector at the inception, the few existing potential companies present in Lesotho started to show lack of interest in taking the students into these internship programs. Amongst the reasons these companies cited included that the lecturers were perceived not to be serious – they were accused of dumping the students to the companies and disappeared, some of the projects were purely academic hence irrelevant to such industries/laboratories that host the students. Given this situation, compounded with the poor chemical industries prospects in the country [13], this situation has forced a review of the structure of this industrial internship to include small-medium enterprises (SMMEs) and community-based organisations (CBOs). This manuscript intends to provide a bird’s eye view of the potential impact this programme can make towards improving the Lesotho’s economy landscape through the internship program. The examples are drawn from a five-year period commencing from 2010.

THE CONCEPTUAL FRAMEWORK

This essay is based on the premise that properly formulated programs coupled with mentoring are necessary to imbue the entrepreneurial mind in the graduate while the traditional programs and instruction will do very little if at all anything. Without proper inspiration and mentorship, the graduates will always have a lot of theory, which they can hardly find its relevance in entrepreneurial activities. This brings an interesting dimension, whether the staff who instruct these programs are properly trained and have a will to embrace and own this challenge. Or whether
this is just a wishful thinking that the graduates should be able to miraculously develop the skills and the drive to go into entrepreneurship without much training and mentorship. We argue herein that the universities should do their bit to introduce entrepreneurship into the curriculum, and fortunately for the chemical technology programme this could be achieved using the industrial internships as it will be shown later.

METHODOLOGY

A qualitative survey was performed using the reports of the projects that were accessible to the researchers through the Departmental collection. These projects had been carried out both internally during the final teaching year and externally carried out with the industrial partners during the attachment period. Relevant topics were identified by reading the titles, abstract and conclusions thereof. Where there were doubts relevant staff were engaged to verify or clarify what was not sufficiently clear to the researchers. The topics were separated by their area of specialization, theoretical or practical as well as potential applicability to chemical industry. The enrolment statistics was obtained from the Faculty Office and validated with those obtained from the Head of Department. The views of the institutions offering internships were also documented from verbal communications and the record of the proceedings during the students’ internship report presentations at the end of the internship period. Data interpretation was mainly carried out using simple Microsoft Excel® 2010 software embedded in the computer’s operating system.
RESULTS AND DISCUSSION

The student enrolment since the inception of the program

Owing to the structure of the program, namely, the need for industrial internship, the program had been made accessible to only less than 10 students at the inception. This was to enable the placement of the students into the few opportunities for the industrial attachment that were possible, while also enabling the successful completion of the internal research projects taking cognizance of the limited infrastructure both physical space and instrumentation. Despite the study focussing on the 5-year period, the enrolment profile was made from the inception of the program to 2015 when the study was conducted due to easy availability and verifiability of the data. Figure 2 shows the trend of the enrolment since 2002 when the program started.

![Figure 2: The enrolment in the BSc Chemical Technology program from 2002-2015](image)

As can be seen, the enrolment has never been consistent since the 2002 when the program started. As discussed, the program was limited to a maximum of 10 students at the beginning with limited allowance to about 15 as the staff complement increased slightly with the recruitment of
chemical engineers in the staffing profile. However, there were years where the numbers could not improve at all such as 2007 when the total population was 4.

Assessment of the type of projects undertaken both internally and during the internship

Figure 3 shows the classification of the type of projects undertaken classified according to whether the project was purely academic (basic), applied or has a potential for commercialization or entrepreneurship. These projects were projected over the five years commencing 2010.

![Figure 3: The classification of the type of projects undertaken over the 5-year period](image)

As can be seen, there has been a slow shift towards projects with a potential for commercialization or entrepreneurship from 2012. This was after the institution recruited a chemical engineer. A very small percentage of projects (about 10%) were purely academic in nature, and these were only reported in 2013. Considering that there were only 7 students then, this translates to only one project.
Classification of the applied projects by field of application

Figure 4 shows the classification of both the applied and potentially commercial projects by area of application for the academic year 2013-2014. The Department had just made a resolution to allow the students to take internships with the SMMEs and the CBOs having observed that such categories of business were highly appreciative of the internship program in that most of the organisations approached believed they would gain significantly from the students attached to their establishments. The total number of students that undertook the internship in that year was thirteen (13) with a majority (9) being attached to SMMEs and CBOs except two (2) that were attached at the ceramic company and one (1) attached at a pharmaceutical company.

As can be seen, the most dominant areas are water purification tied with ceramics at 25% each, followed by waste management in general at 21%, food analyses came in at third place with 13% with the rest scoring equally at 4% each.
Classification of the projects with potential commercialisation

This section dealt with the projects with immediate application for business, or where there was already some small-scale production taking place before, during or immediately after the internship program, in such establishments. Figure 5 depicts the different areas under which the projects with industrial potential were performed in the academic years 2013/14 and 2014/15 where a total of 28 projects were undertaken. The reason this period was chosen was because it followed the decision to target the community-based organization and small-scale manufacturers other than medium-based enterprises that seemed to be reluctant as has been pointed out.

![Figure 5: Classification of the projects with potential for commercialisation and entrepreneurship](image)

From Figure 5, it seems the area of ceramics and stone technology dominate the areas of application (38%) followed by chemical analyses (31%). These ceramics’ projects included preparation of artificial sand from sandstones, exploration of agates for jewellery making, exploration of local clays for pottery, the production of alternative ceramic bricks using different chemical treatment, just to mention but a few.
The projects in food industry included mostly chemical analyses of the prepared foodstuffs by the CBOs to satisfy the trading licenses requirement with the Ministry of Trade, some of which the results have been published in applied chemistry journals [20, 21]. Other projects included preparation of topical creams and jellies, recycling and re-beneficiation of solid waste, modelling and factory design for different chemical products [22], as well as formulation and characterization of multi-purpose detergents [23, 24], improving tannery processes for a rural small-scale tanner, preparation of arts and artefacts using polymers for improved portability and stock production of certain products, as well as improving and refining the engineered stone product which has been an on-going project that resulted in the establishment of a public company Afri-Quartz (Ltd) that is yet to resume operations pending long bureaucratic process required by law. All these projects came consequent to a shift to more entrepreneurial projects, which was identified as an opportunity to make meaningful impact on the face of difficulty presented by dysfunctional infrastructure and poor funding that impede cutting edge research [13], and also heeding the call by the country’s king that the prevailing unemployment rate in the country has become a national crisis [25].

Exploring the Outlook for Future Prospects

From the analyses of the impact of the shift in focus from purely academic or industrial internship to manufacturing and entrepreneurship through partnerships with SMMEs and CBOs, there seems a small light at the end of the tunnel. Since the beginning of 2015 calendar year, there are three registered companies established by the recent graduates of this program, namely, Chem-Cleaner (Pty) Ltd, Heavenly Touch Soap Manufacturers and Reed Basketry (Pty) Ltd, while a few more have started operating although without trading licences; these manufacturers still receive
considerable support from the University/Department. The latter of the mentioned three has ventured into Arts and Crafts using reed having secured seed funding from local business. Besides these graduates, many more have been winning competitions for innovative entrepreneurship ideas [26]. The Department through the Technology Incubation Group has also been offering training workshops for ordinary Basotho who are interested in venturing into chemical entrepreneurial activities such as making soap [27].

The establishment of the Technology Incubation Group in the Department of Chemistry and Chemical Technology working in the area of ceramics and engineered stones technology has sparked a wave on entrepreneurship. The same Department has initiated a University-wide initiative for establishment of the Innovation Hub the policy of which is under development. Besides this, the Department was highly instrumental in establishment of the webpages NUL Research and Innovations as well as NUL Science, Innovation and Entrepreneurship on social media where research output and initiatives are being profiled on weekly basis while in the latter, the students are advised to advertise their entrepreneurial ideas, advice pieces or even seek assistance in addition to the same issues posted on the Research and Innovations page.

Since the inception of these two communication tools, there is a positive vibe that seems to have inspired the students and staff to work even harder. There has been a production of yoghurt from a sister department in the Faculty of Agriculture which is already trading on the University campus and soon to reach the external market after receiving some capital investment to build a plant [28]. Recently the Pius XII chick and later other chicks were hatched from an artificial incubator developed by a sister Department of Physics and Electronics [29].
GENERAL DISCUSSIONS AND CONCLUSIONS

In conclusion, it can be stated that indeed chemical sciences can contribute positively to the economic outlook of the country and thus contribute with impact to the crisis of unemployment situation in Lesotho. A shift from classical chemistry projects to a more practical and applied chemistry has led to the birth of a new spirit of entrepreneurship. The multiplicity of the projects undertaken points to the availability of wide spectrum of competencies which make the University a strategic partner to the Government as it seeks ways of turning around the crisis of unemployment into entrepreneurship opportunity. While economists argue that entrepreneurship is not a survival avenue where people just get in to survive hunger which is one of the reasons put forth in explanation of why so many local entrepreneurs fail to graduate from small business to middle and higher.

As can be seen, the number of students taking this programme is very low, as it has been argued, this is precipitated by the lack of adequate infrastructure to take more students. Even then, not all the students enrolled in the programme are undertaking projects with entrepreneurship potential. There is still a lot of discomfort among staff as to what the role of entrepreneurship is in the teaching of chemistry as a subject. Many still argue that the programme is intended to equip students as chemical technologists and not, put bluntly, chemical industrialists or artisans. This thus suggests a need for a thorough self-evaluation by the Department if the issue of entrepreneurship should be driven forward in line with the National Strategic Development Plan of 2012-2017 [30] and the NUL Strategic Plan 2015-2020 [31].

However, besides these internal barriers, there are also extra-territorial barriers that thwart most of the initiatives and somehow lead to a general feeling of lethargy. The most important one is the poor funding status of the University which negatively and largely impact general resourcing.
of infrastructure development, both physical infrastructure and instrumentation, in addition to poor retention and recruitment of adequately trained staff.

The other important aspect is the lack of funding opportunities for the students’ business ideas. The University has been talking about the establishment of an incubation centre/hub, but this could simply be a dream with the elusive funding sources. Without the implementation of the much talked about National Innovation Hub as proposed in the National Science and Technology Policy [32] that was drafted some more than ten years ago [33], this will forever remain a dream.

There needs to be coordination between different governmental institutions that are entrusted with business development in Lesotho, namely, Basotho Enterprises Development Corporation and Lesotho National Development Corporation as both are making a lot of efforts, be they in feasibility studies or workshops, about establishing business incubators for Basotho entrepreneurs. One would recommend that these state institutions should work closely with another forgotten department in Government, namely, the Appropriate Technology Services to arrive at a common ground than working in silos as it is currently happening. This department could do with a bit of space and infrastructure development, so that it can be able to carry out its mandate. Since ideas are coupled with innovation hubs, one cannot help but think this is a perfect opportunity to partner with the University as universities are places where both creative minds and youthful energy co-habit in the form of professors and students. Besides, this has already been argued in details in this piece and elsewhere.

REFERENCES


27. NUL Research and Innovations. As they learned to make soap from NUL TIG! Posted on March 08, 2016 and retrieved from the NUL Research and Innovations webpage. Available on 20 June 216 from https://www.facebook.com/LesothoResearchandInnovations/.
CLASS ATTENDANCE AND ACADEMIC PERFORMANCE OF SECOND YEAR UNIVERSITY STUDENTS IN AN ORGANIC CHEMISTRY COURSE

Ayodele Olufunmilayo D.
Oduduwa University Ipetumodu, Ile-ife Osun-State, Nigeria
olufunmilayopapers@gmail.com

ABSTRACT

The study of determinants of university students’ performance has been an ongoing research in the last decade. Whether or not class attendance is a major factor has been debated over the years, but the empirical studies have been few and inconclusive. This study investigated the impact of classroom attendance on academic performance of university students in an Organic Chemistry course. It also looked into the moderating effect of gender on attendance and academic performance. Data was collected through expo-facto survey involving real time documentation of attendance for each student at each class lesson throughout a particular (3 months) semester. Data collected were analyzed using the Statistical Package for Social Sciences (SPSS) 17.0 to present the descriptive and inferential statistics. The results revealed a significant effect of attendance marks on academic scores at p<0.05 (t=0.00). However there was no significant effect of gender on academic scores (t=0.484), p<0.005 and also, no significant effect of gender on attendance (t=0.986) at p<0.05. Recommendations were made for policies and classroom practices that would improve class attendance of university students. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

The issue of poor class attendance rate in higher institutions of learning has been and is still a major concern for educators and educational researchers all over the world [1-2]. This is because most educators basically belief that an above average attendance rate would enhance student academic performance in that particular course [3-5]. According to Crede, Roch and Kiesczynka there is skepticism on the part of students and researchers on the importance of class attendance as reflected in the high-class absenteeism rates [6] ranging from 18.5% [7] and 25% [8] to 59-70% [9].

Tertiary institutions in Nigeria today have ascribed great importance to class attendance with some institutions mandating above 70% attendance rate as criterion for writing semester examinations, while some make it a percentage of the continuous assessment. Others exhort lecturers to motivate students to attend lectures by all means. However, in this day of global education through technological advancement in E-learning, on-line tutorials and so on, the question is ‘Does attending classes really have a significant impact on students’ academic performance?’

Absenteeism is common across university classes. Some of the reasons cited in the literature are illness, tiredness, prioritizing other academic work, anticipation of low academic gain, lack of interest/motivation or boredom [10-14]. A major reason for student absenteeism in classes might be the availability of online material, access to PowerPoint presentations, and YouTube. Consequently, this raises the issue of whether missing class (physical absence from the classroom), has impacts on student learning as it used to do before the recent technological advances.
Some researchers posited that attending classes not only allow students to obtain information that is not contained in textbooks or lecture materials presented on-line but also allow students varied contact with materials (lectures, review of notes, demonstrations and so on) [6].

Arulampakam, Naylor and Smith stated that missing class has an adverse effect on performance only for more able students [15]. They further reported that there seems to be no effect of missing class for lower ability students. Hence, the research reports on the influence of class attendance on academic performance in higher institutions are not conclusive. According to Ogbogu performance is vital because the level of success that students achieve from the university has far reaching implications for their personal and professional lives [16]. It has also been reported to have impact on the career choice, personal income, level of success, as well as the degree of participation in community life [17].

This study therefore aims to provide an empirical evidence of effect of class attendance on performance of university students at a private university in Nigeria, and also find out if gender has any extraneous effect on both attendance and performance.

LITERATURE REVIEW

There have been varying policies and practices in higher institutions of learning today concerning attendance of students. This is because of the common assumption that undergraduate students benefit from attending lectures. However, until the early 1990s there was little evidence to establish whether attendance really has effect on students’ academic performance.

Park and Kerr conducted a research on determinants of academic performance using “A Multinomial Logit Approach” and reported that the role of class attendance was statistically significant in explaining students’ grades in those classes. Specifically, their findings demonstrated
that the lack of attendance was statistically significant in explaining why a student received a D rather than an A, a B or a C grade. The statistical tests employed revealed that regular class attendance was a significant determinant in minimizing a student’s chance of receiving D or F,[18].

Following his report, Romer in his research reported a significant difference in the mean GPA of students with strong attendance over those with poorer attendance [3]. However, Hammen and others reported a weak but negative correlation ($r = -0.33$) between examination score in psychology and absenteeism in class [19]. Since then, there has been a growing body of evidence on the quantitative impact of attendance on performance of higher education students [9, 20, 21]. Most of these researchers reported positive effects of class attendance on performance and as led some authors to call for policies to improve on attendance of students or make it mandatory as a criterion for writing semester examinations.

Moreover, it is assumed that motivated and hardworking students are more likely to attend class and to score more highly in their courses. In a study conducted by Rodgers , using data on attendance in an introductory statistics module at an Australian university, he a strong positive association between attendance and performance. However, he further stated that attendance alone does not improve performance [20].

Stanca used a survey-based panel data set of students taking microeconomics at an Italian university and reported a significant positive causal effect of attendance on performance [22]. However, Martins and Walker reported that there was no significant effect of class attendance on performance for students in the Economics department at a university in UK [23].

Moreover, in a meta-analytical review of the relationship of class attendance with grades and student characteristics, Crede and others discovered that the highest performing students had either very good or very poor class attendance and those students in the lowest quintile of grades
were most likely to have average (rather than poor) attendance [6]. They also reported that benefits of attendance for grades appear to decrease once an average level of attendance has been attained. That is, the difference in grades between students with poor attendance and students with average attendance was larger than the difference between students with average attendance and students with very good attendance.

Jaykaran and others carried out in an institute where attendance is proposed to be made mandatory at a minimum of 75% attendance rate as criterion for students to sit for semester examinations. The students were divided into two groups; students who had at least 75% class attendance and those who had less than 75% class attendance. It was observed that there was statistically significant difference between the two groups for mean marks. Mean marks were higher in the group where attendance was 75% or more (unpaired t-test p<0.0067) [24].

Also, Adegoke, Salako and Ayinde, carried out a study on the impact of attendance on students’ academic performance at a polytechnic in Nigeria, they reported a weak positive correlation (correlation coeff.= 0.298) between scores and attendance of students. They also reported that a student can manage to score 36% even if he fails to attend any lectures and must have a minimum attendance of two out of ten to have a pass mark [25].

However, some researchers reported that mandatory attendance policies only has a small positive effect on performance and that it may not significantly enhance course grade [6, 26]. Very few of these researches were done on the shores of this country, and the ones done were mostly on polytechnic students [25].

Furthermore, gender is considered to be a contributing factor to academic performance in undergraduate and postgraduate [24]. Some studies have reported statistical significant difference
in the performance of male and female university students while others found no statistical difference in the performance of both male and female university students [24, 27].

THE PROBLEM, ITS SIGNIFICANCE AND RESEARCH QUESTIONS

The level of success that students achieve from university has far reaching implications on the Nation’s development. Although a number of some personal and social factors have been found to influence the performance of students in the university, one factor that has been reoccurring in the last two decades is class attendance of students. In addition, past research reports have been inconclusive and presently there are varying policies on class attendance in the universities. This paper hopes to contribute to the body of evidence to resolve the ongoing debate regarding the impact of attendance on performance. It would also determine the effect of gender on attendance and performance of students in an organic chemistry class.

This study is significant in that it would give empirical evidence on the impact of attendance on Organic Chemistry examination scores of second year university students of College of Science and Technology Oduduwa University, Ile-Ife. Very few studies have been carried out on attendance and performance in Nigerian universities. Some were done on secondary school students [28, 29] and Polytechnic [25]. The research questions are:

1. What is the average of attendance of the year-two university science students in Organic Chemistry classes?

2. What is the average performance of the year-two university science students in Organic Chemistry?

The following null hypotheses were tested in this study at $p<0.05$ level of significance.

H01: There is no significant effect / relationship of class attendance on examination scores in
Organic chemistry.

H02: There is no significant effect of gender on class attendance in organic chemistry.

H03: There is no significant effect of gender on examination scores in organic chemistry.

**METHODODOLOGY**

This study adopted an ex-post-facto survey design using observed real time roll calling of names of students during each organic chemistry lecture. The sample consisted of 192 year-two students of college of science and technology, Oduduwa University Ile-ife, Osun state, Nigeria.

Two research instruments were used in collecting data for this study. They are;

- Attendance register consisted of columns and rolls for Names of students, Gender, Matriculation number, department and attendees signature.

- Organic chemistry II examination questions consisting of seven essay questions to answer five (total obtainable mark=100).

The attendance of each student was taken at each lecture period by students signing against their matriculation numbers and then, at the end of the lecture, the lecturer does the head count to correlate against the number of signatures. At the end of the semester, the lecturer calculates the total number of signatures per student/total number of lecture periods x 100. This is then recorded against their respective examination scores in Organic Chemistry II.

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 17.0 through both descriptive and inferential statistics. The descriptive statistics are presented in tables. T-test was also conducted to determine significant effects.
RESULTS AND DISCUSSION

The result presented in Table 1 showed that the mean score of the second year science students of Oduduwa University in Organic Chemistry II is 51.39%, while the mean percentage attendance at the classes given throughout the semester is 76.88%.

Table 1: Mean and Standard deviation of Scores and Percentage Attendance of the Students

<table>
<thead>
<tr>
<th>N</th>
<th>Score</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Standard Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>51.394</td>
<td>16.284</td>
<td></td>
<td>1.287</td>
</tr>
<tr>
<td></td>
<td>Attendance</td>
<td>76.875</td>
<td>11.625</td>
<td>0.919</td>
</tr>
</tbody>
</table>

Table 2: Levene’s Test for Equality of Mean Score and Attendance

<table>
<thead>
<tr>
<th>Levene’s test for equality of variance</th>
<th>t-test for equality of means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>22.475</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td></td>
</tr>
</tbody>
</table>

P< .05

The result presented in Table 2 showed that there is a significant effect of attendance on the examination scores of students in Organic Chemistry II. Hence, the null hypothesis Ho1 is rejected.

Moreover, Table 3 below established a significant relationship between class attendance and examination of second year science students of Oduduwa University in Organic Chemistry.

Table 3: Correlation Analysis between students’ examination scores and attendance.

<table>
<thead>
<tr>
<th>Score</th>
<th>Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>.709**</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>160</td>
</tr>
<tr>
<td>Attendance</td>
<td></td>
</tr>
<tr>
<td>Pearson correlation</td>
<td>.709**</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>160</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (1-tailed). There was significant correlation \((r = 0.709)\) at probability level of 0.01.

Tables 4 and 5 below present the result of the t-test conducted on the data.
Table 4: Mean Score of the Respondents in Organic Chemistry II by Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>62</td>
<td>52.532</td>
<td>17.094</td>
<td>2.171</td>
</tr>
<tr>
<td>Female</td>
<td>98</td>
<td>50.674</td>
<td>15.797</td>
<td>1.595</td>
</tr>
</tbody>
</table>

Table 5: Analysis of Variance

<table>
<thead>
<tr>
<th>Levene’s test for equality of variance</th>
<th>F</th>
<th>Sig.</th>
<th>t-test for equality of means</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>MD</th>
<th>Std. error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variances assumed</td>
<td>.469</td>
<td>.494</td>
<td></td>
<td></td>
<td>.702</td>
<td>158</td>
<td>1.859</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>.690</td>
<td>.492</td>
<td></td>
<td></td>
<td>122.276</td>
<td>.492</td>
<td>1.859</td>
</tr>
</tbody>
</table>

P < .05

The results presented in Tables 4, 5 revealed that there is no significant effect of gender on examination scores in Organic Chemistry II. T-test analysis result between the female and male scores. There was no significant difference between the score of both sexes at P = 0.05 (t = 0.484), hence the null hypothesis Ho2 is not rejected. There is no significant variance between the mean scores of male and female students.

Table 6: Mean attendance of male and female second year science students of Oduduwa University in Organic chemistry class

<table>
<thead>
<tr>
<th>Attendance</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Mean Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>62</td>
<td>76.85</td>
<td>14.062</td>
<td>1.796</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>98</td>
<td>76.89</td>
<td>9.858</td>
<td>0.996</td>
<td></td>
</tr>
</tbody>
</table>
Table 7: Analysis of variance in attendance of male and female second year university students in Organic Chemistry class

<table>
<thead>
<tr>
<th>Levene’s test for equality of variance</th>
<th>t-test for equality of means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>1.298</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-016</td>
</tr>
</tbody>
</table>

P< .05

Table 7 revealed that there is no significant difference in the class attendance of male and female second year science students at p<0.05 (t=0.986). Hence, the null hypothesis H03 is not rejected.

**DISCUSSIONS**

The results of this study as presented in the tables shown, revealed that class attendance has a significant positive correlation with examination scores. It also established a significant effect of the attendance of students on their performance in Organic Chemistry examination. These findings corroborate the reports of Crede and others that class attendance correlates strongly with college grades [6], also Andrietti and others also reported that class attendance has a significant effect on performance of university Spanish students [30]. Furthermore, the result of this study revealed that there was no significant difference in the attendance and scores of male and female second year science students of Oduduwa University. This is similar to the findings of some researchers like Niraula and others that there was no statistically significant difference between male and female academic performance of medical students (p= 0.29). Furthermore, it corroborates the reports of Cortright, Lugan, Cox & Dicarlo and that of Nyamapfene that there is no gender bias...
in class attendance and academic performance of Psychology and Engineering students respectively [31, 32].

CONCLUSIONS AND RECOMMENDATIONS

The study carried out an investigation of the relationship and effect of class attendance and examination score of second year science students of Oduduwa University in Organic Chemistry course during a particular semester. The students where scored on attendance at each lecture period. The score of each student was then recorded against the percentage attendance throughout the semester period. The results of the statistical analysis of the data showed that class attendance correlated strongly with and had significant effect on examination score in Organic Chemistry II. In addition, that gender has no significant effect on class attendance and examination scores of students in Organic Chemistry II.

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

1. Lecturers should employ teaching strategies that would enhance the attendance rate of students in their classes.
2. Relevant policies should be put in place to ensure the attendance of students in classes.
3. Classes should be made conducive for learning.
4. Lecture rooms should be well ventilated and spacious enough to accommodate conveniently, the total number of students per lecture.

REFERENCES

http://dx.doi.org/10.5296/jse.v2i2.1564
THE NEED FOR A “BOLOGNA DECLARATION” PRONOUNCEMENT FOR AFRICA’S CHEMISTRY PROGRAMS AT TERTIARY LEVELS.

Fikru Tafesse* and Malose J. Mphahlele
Department of Chemistry, College of Science, Engineering and Technology, University of South Africa, P.O. Box 392, Pretoria 0003, South Africa

*Author for correspondence: tafesf@unisa.ac.za

ABSTRACT

Africa has a pressing need for more chemistry graduates of good quality, to take forward all forms of industrial and economic development. It also needs more chemistry graduates to build up the chemical education system itself by providing a strong new generation of teachers, college lecturers, academics and leaders in chemical industries and research. However, the way chemistry content is packaged to comprise levels 1–3 of a BSc degree program is skewed and does not facilitate learning. To-date over the years of adopting this setup, countries have not made any strides in terms of pass rates and the quality of graduates declines year-by-year. The use of NQF (National qualification framework) levels and credits further complicate this matter. As a result, transfer of credits from one country in Africa to the other has become difficult as an agreed upon principle does not exist for countries to recognize one another’s qualifications. Hence it is recommended that a declaration be adopted to mitigate the above scenario. The role of the Federation of African Societies of Chemistry in championing this endeavor is suggested. [African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

In June 1999, the education ministers of the 29 European countries signed the Bologna Declaration pledging to work toward the creation of a European Higher Education Area. All of the Bologna signatories have pledged to achieve landmark milestones in the completion of the process by 2010. This included introducing a three-degree cycle comprising of bachelors, masters and doctoral degrees, setting quality-assurance standards, and ensuring that countries recognize one another's degrees, giving similar weight to programs across borders. Degree programs varied widely in duration and rigor across Europe, with undergraduate degrees ranging from three years in England to more than five years in many Continental universities, in particular those modeled on the German system.

For some countries, the changes that resulted from these relatively innocuous-sounding goals entailed nothing less than a complete transformation of their higher-education systems. In Germany, for example, most universities had for more than a century awarded the Diplom and the Magister as undergraduate degrees. Diplom program was mainly for subjects in the natural sciences, engineering, economics, and social sciences. The Magister program was for the arts and humanities, and some social sciences. The duration of study for a first degree was roughly five years but was not fixed, helping to foster an international stereotype of German students lingering indefinitely in tuition-free universities. Dropout rates averaged about 50 percent and reached more than 75 percent in some programs. The three year bachelors degree programs worked out pretty well for some study programs, like social-sciences that lacked strictly defined requirements.

However, this created problems for the already existing structured programs such as the natural sciences and engineering. The three year undergraduate degree program was found to be
too short for these structured programs with no time for learners to think to see relations between real fields and the accreditation regimen of frequent exams created additional pressure [1].

For decades, development agencies in the world have encouraged low and middle-income countries to focus their education spending on primary schools and basic vocational skills. They advocated that universities provide lower rates of return on public investment and benefit elites at the expense of the poor. As a result, the South African chemistry programs in tertiary institutions changed their offerings from the traditional four year BSc programs which formed part of the three cycle sequence (BSc, MSc. and PhD) into a four cycle sequence comprising a BSc degree (3 y), BSc honours (1 y), MSc, and PhD. The conventional 4 year BSc degree qualification in chemistry has two tiers in SA comprising the general three years BSc degree in chemistry and at least one additional year for the professional degree, BSc. Honours in chemistry. The admission requirement into BSc honours program prescribes attainment of a minimum of 60% in the major subject in the general degree. To understand the current state of higher education in South Africa, we need to look at where it came from, the high school education system.

SOUTH AFRICAN EDUCATION SYSTEM

With the demise of apartheid came the imperative to discard all tainted systems, including education. Outcomes-based education was introduced as the extreme opposite of “apartheid style” education. Instead of a focus on content, there was to be a focus on the students. Instead of rote learning, everyone was encouraged to express an opinion.

In this kind of system, students barely move beyond what they already know. There is also very little incentive to read and teachers were actively discouraged from using textbooks as sources of knowledge. The teacher simply “facilitated” lessons and students shared what they thought
about a topic. It is sad reality that universities have to turn away many applicants who are outwardly confident, but leave school minimally literate.

Until 2009, South Africa had a two-tiered matriculation system, where learners could choose whether their exam would get them into university or not. Nowadays, Grade 12 learners in the public schooling system all write the same examinations with various classes of passes. The 30% pass rate is associated with the lowest possible pass, a school leavers certificate that does not lead to any further study opportunities. The highest level of pass called a NSC (National Senior Certificate, first examined in 2008) with a bachelor’s pass supposedly enables learners to pursue a university degree. It requires that learners obtain 50% in at least four “designated” (more academically demanding) subjects. Only about 31% of South African learners in public schools achieved a pass at this level in 2013 [2]. Despite its name, many learners who possess the top pass are turned away from universities because they do not meet the minimum admission points for the degree program in which they seek a place. It would be irresponsible to admit students who are not likely to succeed given the demands of the degree.

Nearly all teachers in South Africa’s public schools now have four year qualifications, having either done a four-year initial teacher education qualification or completed a fourth year through an Advanced Certificate in Education. However, Lack of teacher content knowledge remains a major obstacle facing the provision of quality education in South Africa.

At least two things are essential for effective teaching. The first is knowledge of the subject content and processes; the second is general pedagogical knowledge, which is to say an understanding of teaching. Knowledge of a subject is what you might get out of a degree in a particular discipline; pedagogical knowledge might come from teacher training in the form of postgraduate qualifications or experience.
The growing discontent with poor literacy levels and poor knowledge of students who have passed through the outcomes-based education system over the past few years has resulted in numerous curriculum changes to strengthen the knowledge base of the curriculum and promote text-based learning. Universities are not excluded in these changes as they represent crucible for the requisite intellectual and pedagogical knowledge. The question we should ask ourselves as academics and the country is: ‘Has the current two tiered three year bachelors degree and honours program benefitted our country in terms of quality graduates to support our economy?’ We were trained through a similar set-up and continued within it as instructors for years. However, to-date with all our efforts and expertise, we have not yielded any positive results for our country in terms of pass rates and the situation is worsening year-by-year. We need to look at the current bachelor’s degree setup with chemistry as a major, which we have adapted from elsewhere in the past and are comfortable with it even when it is no longer practiced anywhere in the world.

**SOUTH AFRICAN CHEMISTRY PROGRAM OFFERINGS IN TERTIARY EDUCATION**

The root course of poor student throughput and increased dropout rates in chemistry is the current setup of offering the four sub-disciplines of chemistry as asset at both levels 2 and 3. This setup presumably also applies for the 2nd major subject in the sciences that comprise a BSc degree. Related topics per sub-discipline of chemistry which build on each other and that could have been studied in sequence in the same year have just been separated to comprise two distinct levels within the rigid program qualification mix (PQM). Universally, the 1st year of chemistry study comprises of General chemistry 1A (semester 1) and 1B (semester 2) and the corresponding practical
component throughout the year for contact institutions and in the 2nd semester for distance education.

The problem that impedes on Africa’s development and in particular SA science and technology sector and therefore its economy is the grouping of courses/ modules per subject particularly at levels 2 and 3 and the designations of these levels as BSc 2 and 3. The four sub-disciplines of chemistry, viz., analytical, inorganic, organic and physical chemistry, for example, have been grouped together to comprise levels 2 and 3. Students learn bits and pieces from all these disciplines throughout the year or per semester in the 2nd year and the others in the 3rd year.

In some cases, there is no link between the contents covered in the two separate years as instructors follow sequence chapters in the textbooks like a ritual. The repetition of all these sub-disciplines in both levels of a BSc degree program and separation of related chapters or topics to comprise two distinct levels per sub-discipline is superficial and lacks merit. This impedes learning and development as the link between related topics is destroyed and assumed to be continued in subsequent years.

The setup is also based on assumptions that basic concepts relevant for further studies have been covered in the other sub-discipline. The assumed concepts may be offered at a later stage or not at all due to time constraints. In general, the way the sub-disciplines are offered is not synchronized and this turns students into victims of assumptions by the instructors. Who said all the topics (theory and practical component) comprising the current inorganic chemistry 2 & 3 or organic chemistry 2 & 3, for example, cannot be studied or treated in full over the two semesters in a single year? The same question applies for physical chemistry 2 & 3 and analytical chemistry 2 & 3 in another year.
Surely, the current setup, which is based on textbook chapters without weighing their contents, has resulted in inequitable workload for students and instructors. Moreover, it does not facilitate continuity and smooth learning by students.

**Three year versus four-year chemistry BSc degrees**

The three-year bachelor’s degree offered by South African universities is not a universal norm. Many countries around the world including the US and China have a four year undergraduate degree. Hong Kong overhauled its colonial era higher education system significantly in 2012 to start offering four-year undergraduate degrees.

Generalizing about the African continent and its educational systems is problematic. Education systems and their infrastructural or economic contexts are vastly different. This is not only true from country to country and region to region, but also within each country and region. Most African countries follow the three cycle sequence, namely, BSc (4 y), MSc and PhD. Some countries front the three year bachelor’s degree programs with one year foundation program and label it as a four year BSc with no need for the honors program. Some African countries have moved from a four year program into a three year BSc program without bridging the gap which necessitated the honors program. In some cases, the 3-year BSc program has been translated into a 4-year BSc program by just keeping the course structure and content the same, but simply assign credits to the preparatory year.

Unfortunately, this has a big impact in the offerings of post graduate programs for UNISA (University of South Africa) and probably other institutions in SA. UNISA’s College of Science, Engineering and Technology (CSET) as distance education provider, has also contributed to challenging the notion of university as a physical location. Hence, the need for understanding the
different educational systems in Africa and their chemistry offerings is of paramount importance.

A typical structure for a 3 year program is shown in Table 1.

Table 1: A current standard structure for a 3-year BSc as prescribed by CHE

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>Courses</th>
<th>HEQSF credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>A 1a, B 1a, C 1a, D 1a</td>
<td>15 x 4, 60</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>A 1b, B 1b, C 1b, D 1b</td>
<td>15 x 4, 60</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>A 2a, B 2a, C 2a</td>
<td>20 x 3, 60</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>A 2b, B 2b, C 2b</td>
<td>20 x 3, 60</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>A 3a, B 3a</td>
<td>30 x 2, 60</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>A 3b, B 3b</td>
<td>30 x 2, 60</td>
</tr>
</tbody>
</table>

The course label A1a should be read, for example, as: A = discipline A, 1 = 1st year level, a = first semester and b = second semester.

In some contexts, the three-year BSc was front-ended by a one-year “foundation” year, which typically did not carry any HEQSF (Higher Education Qualifications Sub-Framework) credits. The BSc was still valued at 3 x 120 = 360 HEQSF credits, although students follow a structured 4-year program [3].

In the context of SA universities, chemistry students register for general chemistry 1 and its practical component in the 1st year. This is followed by four full sub-disciplines of analytical, inorganic, organic and physical chemistry and their respective practical components in the 2nd and 3rd level of study. The four sub-disciplines at each level have been group into two sets and offered as half-year or semester courses in contact institutions.

In the context of Unisa’s offerings, chemistry students register for theory and practical component for the 4 full modules/courses in a semester and the theory modules are available in both semesters. In addition, the students are expected to complete the 2nd major subject in another course to 3rd year level along with some minor subjects at 1st year level.
It is to be noted that UNISA is not a contact university and this creates additional burden on the load of the student and the lecturers. There are a lot of factors that contribute to the student retention and throughput rates. Some controllable and others haphazard! Understanding those factors and working towards attaining positive results will constitute a paramount importance. Among the problems that are identified is lack of enough time to understand the content of the modules in both contact and distance education systems.

In an attempt to mitigate poor pass rates and student throughputs, that impact negatively on our country’s science and technology sector and therefore its economy, the CHE (Council on Higher Education) has initiated a process to review the current two-tier bachelors program comprising an overloaded three year BSC degree and an honors degree program in favor of a four year bachelor’s degree as discussed below.

A proposed structure for the 4-year Bachelor’s degree by the CHE

The CHE ‘Shape and Size’ task team proposed the introduction of a ‘four-year first bachelor’s degree’ in response to both high dropout rates and changing knowledge needs. The report proposed that: The first two years of the four-year first bachelor’s degree could provide for the development of required generic and foundation skills and include some broad discipline and multi-discipline based knowledge. Years three and four of the degree could include a strong emphasis on single discipline and multi-discipline based specialization, including an introduction to elementary forms of investigation and research methodology. The implication of and relation between the four-year degree and the existing Honors qualification would need to be examined [4].
The problem of poor student-outcomes is a complex and multilayered one which is shaped by many issues. Some among these are [5]:

- the lack of preparedness of students and staff
- the nature and organization of teaching and learning at higher education institutions
- the conceptualization of the education process, particularly in terms of the appropriateness of content and assessment methods and its relationship with different institutional cultures
- the extent or lack of professionalization of academic staff
- the nature and extent of funding
- and the role that system differentiation might have in addressing under-preparedness

The solution have to be based on curriculum reform and the expansion of student support programs [6]. This was re-iterated in the Green Paper for Post-School Education and Training, which states: Inadequate student preparedness for university education is probably the main factor contributing to low success rates.

Various approaches have been attempted by different universities to compensate for this problem. Unfortunately, there is no clear evidence of what the most successful routes are. Clearly, though, universities will have to continue to assist underprepared students to make the transition to a successful university career. This could involve foundation programs, intensifying tutorial-driven models that enable small-group interaction, or increasing the duration of degrees. The funding system must support such initiatives. Universities and programs differ in their student intakes, and each must tailor their support offerings to fit their needs [7, 8].

We concur with the CHE’s proposal for a change from the current setup. However, we hold a different view on how a four year bachelor’s program for chemistry should be structured to facilitate learning and continuity. Below we forward a proposed model for a 4-year degree suitable
for chemistry as a major subject in line with the question we raised above, i.e., Is it possible to offer all the topics (theory and practical component) comprising a specific sub-discipline of chemistry at levels 2 and 3 in a single year over two semesters?

**A proposed structure for the 4-year BSc degree with Chemistry as a major**

Our experience with the training of student trained in the current setup of offering four sub-disciplines of chemistry as a set in both levels 2 and 3 is that students complete BSc degree with poor grasp of concepts. We are required to bridge the gap at honors and postgraduate levels regardless of the origin of the students, whether from contact or distance learning institution. This also applies to undergraduate program wherein students registered for the 2nd and 3rd year of study have poor grasp of concepts treated in the preceding level of study.

We should move away from rigid concepts such as NQF levels and associated credit system and think outside the box. In our view, the current syllabus for inorganic 2 & 3 and organic chemistry 2 & 3, which require matric mathematics can be completed in the 2nd year of a BSc degree and lay foundation for analytical and physical chemistry. Analytical and physical chemistry sub-disciplines, which require high level of mathematics and focus on the quantitative and qualitative analysis or physical aspects of inorganic and organic compounds should be taught in full and in parallel in the 3rd year of a BSc program.

The setup proposed herein, does not preclude joint registration of other pre-requisites and the 2nd major subject. It completely removes the interdependencies and assumptions accompanying the current setup of offering the four sub-disciplines. The proposed setup will not only reduce the workload associated with repetition of the four sub-disciplines in the two levels of a BSc program,
but the costs associated with registering the four theory and four practical components at levels 2 and 3, respectively.

We propose that the fourth year of the BSc program, which will be equivalent to the current BSc honors degree, students should focus on advanced topics to bridge the gap and to lay a foundation for higher degree studies. In the fourth year of study, students will be able to do a research methodology module and register for another course outside the sciences to improve their graduate attributes.

The delivery of chemistry aims to exploit a spiral approach in which concepts learned at one point in time are reinforced and built upon later. Developing one comprehensive unit at the first year for a second or third level undergraduate chemistry program does not serve the teaching and learning process adequately.

We suggest that the different chemistry sub-disciplines should be integrated in developing several short modules to be introduced within a course. The current trend of naming a course as inorganic or organic and restricting the content to the sub-discipline is not fruitful. A study program can be developed to encompass modules (topic areas) in the course from the different sub-disciplines, each time increasing the depth and building on previous knowledge. An agreement has to be reached on the definition of modules and courses accordingly. We suggest that a module (topic area) need to be defined as a subset of a course (learning program).

**RECOMMENDATIONS AND CONCLUSIONS**

The importance of education and educational co-operation in the development and strengthening of stable, peaceful and democratic societies is universally acknowledged as paramount, more so in African countries. The Bologna type declaration for Africa does not aim to
harmonize national educational systems but rather to provide tools to connect them. The intention is to allow the diversity of national systems and universities to be maintained while the African educational structures improve transparency among higher education systems, as well as implements tools to facilitate recognition of degrees and academic qualifications, mobility, and exchanges between institutions.

Higher education will not have a real impact on countries' development unless the following three key things take place:

- First, universities have to function together as part of a coherent system in the public interest.
- Second, access to higher education must be equitable and allow admission for talented students from disadvantaged backgrounds.
- Third, teaching, research and community engagement must address key local and national development needs.

It will be very advantageous if the declaration spells an agreement on a comparable three cycle degree system for undergraduates (Bachelor degrees) and graduates (Master and PhD degrees). The main objectives to be addressed in the declaration are anticipated to be:

- adopting a system of easily comparable Chemistry degrees
- adopting a system with two main cycles (undergraduate/graduate)
- establishing a system of credits for chemistry offerings
- promoting mobility by overcoming legal recognition and administrative obstacles
- promoting Pan-African co-operation in quality assurance
- promoting synergy with chemistry teaching in higher education elsewhere.
The above objectives can be attained within the framework of African institutional competences and taking full respect of the diversity of cultures, languages, national education systems and of university autonomy to consolidate the Chemistry teaching in Africa. The stakeholders of this endeavor are expected to be the respective African universities that offer chemistry programs together with their governments and chemical societies.

It is expected that African union will play a big part to bring all African chemists for this discourse and respond promptly and positively to the success of this endeavor. The Federation of African Societies of Chemistry is expected to be the main role player in this regard. Running a revamped three or four year degrees is anticipated to prevail concurrently during the transition phase-in period. Other disciplines might also embark on a similar trend.

The basic purpose of a PhD is to learn how to undertake research. That is, how to go from the initial conception and formulation of a basic idea or hypothesis, through the process of testing this hypothesis by planning and performing experiments or the development of theory, algorithms or software, to the final act of analyzing a set of observations and reporting of the results obtained to the broader scientific community, whether orally or in written form. In the physical sciences, this is generally done within a limited period of 3 to 4 years during which students work full time on a topic. In the humanities, much longer periods are often required to master a topic and contribute new ideas and insights, while the research component of a PhD in the clinical sciences may be more limited given the time medical doctors have to spend with patients.

In the physical sciences, a PhD is generally undertaken within a research group under supervision of a professor or senior academic. Such a research group may vary in size from just one or two persons to large collectives including tens of bachelor, master and PhD students, post-docs, technicians, and senior scientists. The PhD student has a temporary position at the university
and is often paid by a third party. Most will conduct research for 70-80% of their time and help in teaching or otherwise assist the group for 20-30% of their time. Thus, a PhD is a mixed activity involving learning from more experienced group members regarding how to gather data, analyze observations and to present results stemming from their own research, as well as teaching and supporting the next generation of group members.

During the first year of a PhD, understanding the research topic is the primary goal. During later years, significant contributions to the research of the group are expected. A PhD must have some freedom in the choice of the research topic and the opportunity to pursue his or her own ideas. That this is primarily a learning experience is reflected in a PhD’s salary. While possessing a PhD degree may expand a student’s employment opportunities, undertaking a PhD is not a way to make money. A PhD is for those who are innately curious, who are driven to understand natural phenomena and enjoy the freedom as well as frustration of investigating the unknown. Attempting to obtain a PhD is challenging and exciting, but it is not for everyone. If things do not work out, recognize and accept this early while one can still easily exploit other opportunities of life [9].

A PhD is generally considered the final completion of academic studies. Yet, it requires quite different qualities of a student compared to a bachelor or masters level of education including the ability to formulate goals, to work independently, to search for data in the literature, to be self-critical, to report orally and in writing, tenacity to keep going under adverse circumstances and the ability to deal with the many set-backs which inevitably occur when exploring unknown territory. It definitely is not a third study cycle after having obtained a bachelor and master degree.

REFERENCES


COMPARATIVE ASSESSMENT OF UNIVERSITY CHEMISTRY UNDERGRADUATE CURricula IN SOUTH-WESTERN NIGERIA

Modupe M. Osokoya
Institute of Education, University of Ibadan
modupeosokoya@yahoo.com

Isaac S. Fapuro
Institute of Education, University of Ibadan
bolafapuro@yahoo.com

H. Oluwatola Omoregie
Department of Chemistry, University of Ibadan
tolaomoregie@gmail.com

ABSTRACT

A comparative analysis of the structure of undergraduate chemistry curricula of universities in the southwest of Nigeria with a view to establishing the relative proportion of the different areas of chemistry each curriculum accommodates. It is a qualitative research, involving content analysis with a partial quantitative analysis in terms of numbers of courses of different status in each curriculum. Five federal, three states and two private universities offering Pure Chemistry, were purposely selected. Frequency counts and percentages were used to present the quantitative results. The areas of chemistry covered are Introductory, Inorganic, Physical, Organic, and Quantum and Analytical chemistry. Some direct applications of chemistry include courses in Environmental, Industrial, Polymer, Rubber and Brewing Technology. However, there are discrepancies with respect to comprehensiveness of courses’ contents in the different areas of chemistry. The federal and private universities adhere more strictly with the National University Commission (NUC) respective course content requirement. All the universities, except one, do not have 100% compliance with respect to total number of compulsory, elective and practical courses. The universities are enjoined to have 100% compliance with NUC guidelines and may include varieties of elective courses to meet the different career aspirations of the chemistry undergraduates.

[African Journal of Chemical Education—AJCE 7(1), January 2017]
INTRODUCTION

Science and technology have always been part of the quest for development since industrial revolution. In the 21st century, both Science and Technology together constitute the pivot of manufacturing industries, medicine (both human and veterinary), agriculture, communication, housing, urban and regional planning, public utilities like water and electricity, just to mention a few. At the secondary education level the basic science subjects are Chemistry, Physics and Biology. At the tertiary education level particularly in the universities where science-based courses are studied, Chemistry is the only school subject that is embedded in all the science-oriented disciplines. Furthermore, Chemistry is also a discipline on its own at the university level with various specialisations like Pure and Applied Chemistry, Analytical Chemistry, Industrial Chemistry, Biochemistry, Petroleum Chemistry, Geochemistry and others.

Hybrid names such as “agricultural chemistry, archaeological chemistry, consumer chemistry, cosmic chemistry, geochemistry, human chemistry, nutritional chemistry, environmental chemistry, fuel chemistry, forensic chemistry, food chemistry and oceanic chemistry,” attest to both the diversity and usefulness of chemistry and its close ties to other fields of science and technology. [1] The diversity of fields related to chemistry shows that chemistry by its very nature is the central science [2]. It is central to the fundamental understanding of all other fields of Science and Technology [3].

Chemistry is “the science of matter that deals with the composition and properties of substances and the changes they undergo”. [4] It is the science of matter and its transformations [5]. Matter, from the chemical point of view, consists of the substances we encounter in our daily lives, such as solids, liquids, and gases, as well as the atoms and molecules of which these
substances are composed. Chemistry is thus defined as the science of matter and changes which it undergoes.

Chemistry provides answers to many fundamental questions about the material world. It is not out of place then to support the school of thought that for a choice of career as a chemist, biochemist, research scientist, doctor, pharmacist, toxicologist, teacher, lawyer, entrepreneur or even engineering disciplines, a degree in chemistry can be the starting point. The curriculum, through which undergraduates are awarded the Bachelor of Science degree, is expected to lay a good foundation for the areas of study relating to chemistry. It is also expected that the curriculum will equip such student to contribute meaningfully to national and global development as a scientist.

Education is regarded, globally, as a potent instrument for introducing and sustaining social change in human societies, shaping its destiny as well as serving as a vehicle for enhancing upward social and economic mobility [6] Education imparts knowledge, teaches skills, and instils attitudes to its recipients. Imparting knowledge means putting across facts, current thinking, theories, principles or laws; teaching skills is imparting practical skills, comprehension and ability to see implications or solve problems; instilling attitudes include inculcating tolerance, open-mindedness, scientific detachment and healthy scepticism. [6] [7].

The purpose of education in Nigeria also includes unparalleled development of science and its application to industry and technology for better living. The National Policy on Education spells out the purpose of Education in Nigeria as an:

“instrument par excellence for effecting national development; a tool to achieve its national objectives; satisfying the needs of the individual and setting its goal in terms of the kind of society desired in relation to the environment and realities of the modern world and rapid social changes” (p. iv).”[8].
One of the main objectives of university education in Nigeria is the production of skilled manpower to drive the economy as well as contribute meaningfully to the scientific and technological development of the nation. For Chemistry at undergraduate level in particular, the primary objective is the production of graduates who are presumed to be adequately prepared for effective performance as Chemists in future employments. Such graduates are expected to be resourceful, adaptive and innovative in any area they may find themselves. Graduates who hold degrees in Chemistry occupy a variety of positions in industries, government and the academia. Those who work in the chemical industry serve as laboratory chemists where they carry out experiments to develop new products (research and development), or analyse materials (quality control) or carry out diagnosis.

Relying on the National Universities Commission (NUC) Decree (Act) No. 16 of 1985 as amended Decree No. 48 of 1988 which empowers the Commission to set minimum standards for all programmes in Nigerian universities, the Commission in collaboration with the universities developed the Minimum Academic Standards (MAS) for all the existing programmes in 1989 and this was subsequently approved by the Federal Government of Nigeria later in the same year. The MAS was later reviewed in 2001. The review produced a new document which is an outcome-based benchmark statement for all the university programmes in line with contemporary global practice. The benchmark-style statements were considered inadequate for curricula development and accreditation purpose and were therefore merged with the revised MAS to produce a new document known as Benchmark Minimum Academic Standards (BMAS) for all disciplines.

A degree program in chemistry is expected to foster in undergraduates an appreciation of the centrality of chemical science to human well-being as well as its inevitable linkage to and interactions with other branches of science. Summarily, graduates of Chemistry are expected to
have the ability to apply knowledge and skills to solving theoretical and practical problems in Chemistry and other allied industries in relation to national and societal needs. [9].

The narrow and broad conceptions of curriculum [10] are as follows:

**Narrow conceptions of curriculum**

1. The subject matter that teachers and students cover in their courses
2. The contents of instructional program
3. The set of courses, exercises or field work, etc. that make up a certain part of a program
4. An integrated course of academic studies
5. A program of courses comprising the formal requirements for a particular area of study.

**Broad conceptions of curriculum**

1. A comprehensive over-view, including activities planned for delivery to the students, the scope of content, and the sequence of materials and balance of subject-matter and motivational instructional and assessment techniques to be used to achieve a set of ordered, intended outcomes.
2. A structured plan of intended learning outcomes, under-pinning knowledge, skills, behaviour and associated learning experience. (p.524-5)

The effective teaching and learning of any subject at any level is anchored on the curriculum put in place for the subject. Curriculum is to be regarded “as a school-generated experience that ensures a permanent positive transformation in us and turns us into life-long learners facing the challenges of existence headlong as they arise in a dynamic world environment context”. [10] The Education strategist is of the opinion that a well-developed curriculum should engender a spirit of life-long learning, which enables those who experienced the curriculum to cope effectively with life-long challenges as they arise. Put very simply, a curriculum can be
referred to as guide or manual that tells the teacher about the nature and characteristics of the learners to teach, the content to teach, the methods and strategies to use in teaching and assessing learners. In the same vein, it was ascertained that “without an effective curriculum, students would not be able to understand or meet the challenges of the society”. [11].

Curriculum delineates the skills and concepts taught and evaluated to enhance students’ achievement. It is composed of a content area, philosophy strands with definitions of goals, scope, sequence, learning outcomes and assessment tools. It is intentionally designed to meet district, state and national standard. A well-developed curriculum will specify the knowledge, skills, insights and attitudes that learners will be expected to acquire (i.e. learning objectives or outcomes), the in-class and out-of-class learning activities that will aid learners to learn (i.e. learning experiences) as well as teacher’s activities[10].

This study involves the comparative analysis of the Chemistry curricula of some Nigerian Universities. The importance of curriculum evaluation has to do with the determination of the value of the curriculum itself as well as the appropriateness for the particular group of students for which it is being used. It is also to show the relevance of the instructional methods relative to the objective of the educational programmes, and the appropriateness of materials recommended for instructional purpose. The objectives of curriculum evaluation on the other hand include the determination of the outcomes of a programme, help in the decision on whether to accept or reject a programme, ascertaining the need for revision of curriculum content, help in future development of the curriculum materials for content improvement, and improvement of methods of teaching and instructional techniques [10].

In Nigeria, as earlier stated the minimum standard of the curricula for courses at the university level was designed by the central governing body for universities i.e. the National
Universities Commission (NUC). Nigeria as at May 2015 has a total of one hundred and thirty-eight (138) registered Universities. This number is made up of forty (40) federal, thirty-nine (39) state and fifty-nine (59) privately owned. The Universities are scattered across the country with a sizeable chunk located in the Southwest. Since the minimum standard of curricula for courses are specified by the NUC which is the statutory supervisory body for universities, the following questions among others naturally arise with particular focus on Chemistry:

i. To what extent do the Chemistry curricula use in Nigerian Universities compliant with the minimum guidelines specified by the National Universities Commission?

ii. How do the Chemistry curricula in use in federal, state and private Universities in Nigeria compare with the NUC specified guidelines?

iii. How is the chemistry curriculum exposing the undergraduates to the different aspects of chemistry that can consequently prepare the undergraduates foundation for other science related disciplines?

iv. How is the curriculum equipping the students with basic skills for scientific/ technological development so as to achieve part of the aim of tertiary education in Nigeria?

These questions arise as a consequence of the importance of chemistry as a core subject for Science and Technology. If the country is to develop technological capacity, there is need to ensure high quality and uniformity of the curriculum in schools with particular reference to Chemistry at the university level which is the focus of this study.

THE PROBLEM

The effective teaching and learning of any subject at any level depends heavily on the curriculum put in place for the subject. A search through literature on curriculum studies revealed
an in-depth research into aspects such as curriculum development, challenges or constraints of curriculum implementation, curriculum innovation, assessment or evaluation of curriculum, and comparative analysis of the curriculum in some subject areas especially at the secondary school level. However, there is a need for a study in the area of comparative analysis regarding Chemistry curriculum most especially at the undergraduate level in the Universities in Nigeria.

This study is therefore focused on a comparative analysis of the Chemistry curriculum of Nigerian Universities with emphasis on those located in the Southwest of the country. This is to find out if such curriculum is in compliance with the minimum guidelines specified by the National Universities Commission (NUC) which is the supervisory body for Universities in Nigeria and to what extent. The study also compares and contrasts the Chemistry curricula of the different units of the sampled Universities, which are aimed at achieving the same goal of the award of the Bachelor of Science degree in Chemistry with the NUC guidelines using the variables such as structure, total number of credits units allotted to different aspects of chemistry among others as guide.

RESEARCH QUESTIONS

Considering the problems discussed above, the following questions become relevant:

i. To what extent do the structure of Chemistry curricula used in Nigerian Universities is in compliance with the minimum guidelines specified by the National Universities Commission?

ii. How do the Chemistry curricula of the federal, state and private Universities in Nigeria compare with the NUC specified guidelines with respect to the pattern and proportion of the different areas of chemistry in the curriculum of South-Western Nigerian Universities?
iii. Does the structure and content of the respective university undergraduate curriculum expose students to all major areas of chemistry?

iv. Does the structure and content of the undergraduate chemistry curriculum designed for development of vocational skills in the students?

**METHODOLOGY**

This is descriptive study. The curricula of the sampled universities were content analyzed for the sake of comparison to determine their points of congruence and divergence. Descriptive statistics were also used to present some data thereby making the design a mixed method approach – quantitative and qualitative.

The population of the study comprises all the approved universities in the South-west of Nigeria across the different ownerships of federal, state and private. Purposive sampling technique was used to select five universities from federal, three from state and two privately-owned making a total of ten. The federal universities are designated FU 1, FU 2, FU 3, FU 4 and FU 5. The state-owned universities are designated SU1, SU 2, and SU 3; while the privately owned universities are designated private PU 1 and PU 2. These are universities offering Pure Chemistry. Their Chemistry curricula were compared with the minimum guidelines specified by the National Universities Commission. [12].

The variables of interest in this study are

i. number of chemistry courses and the total number of credit units attached to them

ii. number of listed compulsory Chemistry courses and the total number of credit units attached to them

iii. number of available elective Chemistry courses and the total number of credit units attached to them
iv. number of Chemistry practical courses and the total number of credit units attached to them

v. proportion of courses in the different aspects of chemistry in respective university curriculum and

vi. proportion of courses that can possibly equip the undergraduates with vocational skills among the courses in the respective university curriculum

The curricula from the different sampled Universities served as the instruments for the study. The data from this study were collected by the researchers through content analysis. Descriptive statistics involving frequency counts and percentages were used for the analysis of the data collected. These were supported by pictorial representations for the purpose of clarity.

RESULTS AND DISCUSSION

Table 1: Total number of Chemistry courses offered and the respective credits unit allotted

<table>
<thead>
<tr>
<th>University/NUC</th>
<th>Total No. of Chemistry Courses</th>
<th>% compliance with NUC in terms No. of Chemistry Courses</th>
<th>Total No of credit Units</th>
<th>% Compliance with NUC in terms Total No of credit Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUC</td>
<td>51</td>
<td>100.0</td>
<td>129</td>
<td>100.0</td>
</tr>
<tr>
<td>FU 1</td>
<td>34</td>
<td>66.7</td>
<td>104</td>
<td>80.6</td>
</tr>
<tr>
<td>FU 2</td>
<td>51</td>
<td>100.0</td>
<td>133</td>
<td>103.1</td>
</tr>
<tr>
<td>FU 3</td>
<td>49</td>
<td>96.1</td>
<td>123</td>
<td>95.3</td>
</tr>
<tr>
<td>FU 4</td>
<td>54</td>
<td>105.9</td>
<td>116</td>
<td>89.9</td>
</tr>
<tr>
<td>FU 5</td>
<td>48</td>
<td>94.1</td>
<td>103</td>
<td>79.8</td>
</tr>
<tr>
<td>SU 1</td>
<td>43</td>
<td>84.3</td>
<td>98</td>
<td>76.0</td>
</tr>
<tr>
<td>SU 2</td>
<td>31</td>
<td>60.8</td>
<td>70</td>
<td>54.3</td>
</tr>
<tr>
<td>SU 3</td>
<td>35</td>
<td>60.6</td>
<td>91</td>
<td>70.5</td>
</tr>
<tr>
<td>PU 1</td>
<td>46</td>
<td>90.2</td>
<td>108</td>
<td>83.7</td>
</tr>
<tr>
<td>PU 2</td>
<td>47</td>
<td>92.2</td>
<td>105</td>
<td>81.4</td>
</tr>
</tbody>
</table>
Figure 1: Total number of Chemistry courses offered and the respective credits unit allotted FU-Federal University; SU-State University; PU-Private University

Table 2: Analysis of universities course outlines

<table>
<thead>
<tr>
<th>UNIVERSITIES</th>
<th>Total No. of courses</th>
<th>Compulsory courses</th>
<th>Elective courses</th>
<th>Practical courses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Of Chemistry</td>
<td>Credit Units</td>
<td>No/% of Unit</td>
<td>No/% of Credit Units</td>
</tr>
<tr>
<td>NUC</td>
<td>51</td>
<td>129</td>
<td>22 43.1</td>
<td>62 48.1</td>
</tr>
<tr>
<td>FU 1</td>
<td>34</td>
<td>104</td>
<td>28 82.4</td>
<td>83 79.8</td>
</tr>
<tr>
<td>FU 2</td>
<td>51</td>
<td>133</td>
<td>21 41.2</td>
<td>66 49.6</td>
</tr>
<tr>
<td>FU 3</td>
<td>49</td>
<td>123</td>
<td>24 49.0</td>
<td>74 60.2</td>
</tr>
<tr>
<td>FU 4</td>
<td>54</td>
<td>116</td>
<td>34 53.0</td>
<td>85 73.3</td>
</tr>
<tr>
<td>FU 5</td>
<td>48</td>
<td>103</td>
<td>40 83.3</td>
<td>87 84.5</td>
</tr>
<tr>
<td>SU 1</td>
<td>43</td>
<td>98</td>
<td>34 79.1</td>
<td>78 79.6</td>
</tr>
</tbody>
</table>
Figure 1 indicates that in terms of the total numbers of Chemistry courses in each of the sampled universities, only FU 2 has a percentage compliance of 100%. All the other sampled Universities have a compliance level range of 60.8% -105.9%. Also with respect to number and credits units of compulsory courses all the universities except two have more courses and allotted credits more than those of the NUC guideline. (See figure 2). Whereas FU 1 has fifty-one (51) number of courses which tallies with the NUC recommendation, others have smaller units with SU2 and SU3 being as low as 31 and 35 respectively. The lower number of courses in SU 2 is attributable to the merger of some of the recommended courses. These observations show that there are differences in what is offered the students in those Universities compared to what is recommended by the NUC. This is contrary to the spirit of the NUC 2007 BMAS document which was evolved by a process which took cognisance of the inputs from all the existing universities as at then to ensure uniformity of the programmes in the various universities.

However, in the cases with higher number of courses particularly with respect to compulsory courses than the NUC recommendation, the universities really aim at giving the graduates sound basic background in chemical knowledge without option of courses in chemistry.

It is expected that the students can still offer courses from other departments, to meet graduation requirement.
<table>
<thead>
<tr>
<th></th>
<th>General (Intr.)</th>
<th>Physical</th>
<th>Inorganic</th>
<th>Organic</th>
<th>Analytical</th>
<th>Environmental</th>
<th>Quantum/ Nuclear</th>
<th>Vocation al</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 NUC</td>
<td>2.39</td>
<td>7.13.7</td>
<td>9.17.6</td>
<td>10.19.6</td>
<td>2.39</td>
<td>1.2.0</td>
<td>2.39</td>
<td>6.11.8</td>
<td>12.23.5</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>units</td>
<td>7.5.4</td>
<td>16.12.4</td>
<td>22.17.1</td>
<td>25.19.4</td>
<td>5.3.9</td>
<td>3.2.3</td>
<td>5.3.9</td>
<td>17.13.2</td>
<td>29.22.5</td>
</tr>
<tr>
<td>2 FU 1</td>
<td>No. of Units</td>
<td>-</td>
<td>6.17.6</td>
<td>5.14.7</td>
<td>8.23.3</td>
<td>4.11.8</td>
<td>-</td>
<td>3.8.8</td>
<td>5.14.7</td>
<td>3.8.8</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>21.20.2</td>
<td>17.16.3</td>
<td>24.23.1</td>
<td>13.12.5</td>
<td>-</td>
<td>8.7.7</td>
<td>13.12.5</td>
<td>7.6.7</td>
</tr>
<tr>
<td>3 FU 2</td>
<td>No. of Units</td>
<td>2.39</td>
<td>9.17.6</td>
<td>5.9.8</td>
<td>12.23.5</td>
<td>2.3.9</td>
<td>1.2.0</td>
<td>4.7.8</td>
<td>6.17.8</td>
<td>10.19.6</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>7.5.3</td>
<td>21.15.8</td>
<td>15.11.3</td>
<td>30.22.6</td>
<td>5.3.8</td>
<td>3.2.3</td>
<td>10.7.5</td>
<td>17.12.8</td>
</tr>
<tr>
<td>4 FU 3</td>
<td>No. of Units</td>
<td>3.6.1</td>
<td>8.16.3</td>
<td>8.16.3</td>
<td>10.20.4</td>
<td>3.6.1</td>
<td>1.2.0</td>
<td>7.14.3</td>
<td>3.6.1</td>
<td>6.6.2</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>11.8.9</td>
<td>20.16.3</td>
<td>20.16.3</td>
<td>25.20.3</td>
<td>6.4.9</td>
<td>2.1.6</td>
<td>22.17.9</td>
<td>5.4.1</td>
</tr>
<tr>
<td>5 FU 4</td>
<td>No. of Units</td>
<td>3.5.6</td>
<td>17.13.0</td>
<td>6.11.1</td>
<td>11.20.4</td>
<td>8.14.8</td>
<td>1.1.9</td>
<td>2.3.7</td>
<td>4.7.4</td>
<td>12.22.2</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>7.6.0</td>
<td>17.14.7</td>
<td>13.11.2</td>
<td>26.22.4</td>
<td>17.14.7</td>
<td>2.1.7</td>
<td>4.3.4</td>
<td>11.9.5</td>
</tr>
<tr>
<td>6 FU 5</td>
<td>No. of Units</td>
<td>2.4.2</td>
<td>6.12.5</td>
<td>3.6.3</td>
<td>8.16.7</td>
<td>3.6.3</td>
<td>2.4.2</td>
<td>2.4.2</td>
<td>15.31.3</td>
<td>7.14.6</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>8.7.8</td>
<td>13.12.6</td>
<td>5.4.9</td>
<td>15.14.6</td>
<td>6.5.8</td>
<td>4.3.9</td>
<td>32.31.1</td>
<td>16.15.5</td>
</tr>
<tr>
<td>7 SU 1</td>
<td>No. of Units</td>
<td>2.4.7</td>
<td>9.20.9</td>
<td>6.13.9</td>
<td>13.30.2</td>
<td>3.7.0</td>
<td>1.2.3</td>
<td>1.2.4</td>
<td>3.7.0</td>
<td>5.11.6</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>8.8.2</td>
<td>20.20.4</td>
<td>13.13.3</td>
<td>28.28.6</td>
<td>7.7.1</td>
<td>2.2.0</td>
<td>2.2.0</td>
<td>7.7.1</td>
</tr>
<tr>
<td>8 SU 2</td>
<td>No. of Units</td>
<td>2.6.5</td>
<td>5.16.1</td>
<td>4.12.9</td>
<td>8.25.8</td>
<td>1.3.2</td>
<td>1.3.2</td>
<td>1.3.2</td>
<td>4.12.9</td>
<td>5.16.1</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>7.10.0</td>
<td>10.14.3</td>
<td>8.11.4</td>
<td>17.24.3</td>
<td>2.2.9</td>
<td>2.2.9</td>
<td>10.14.3</td>
<td>12.17.1</td>
</tr>
<tr>
<td>9 SU 3</td>
<td>No. of Units</td>
<td>2.5.7</td>
<td>6.17.1</td>
<td>5.14.3</td>
<td>12.34.3</td>
<td>2.5.7</td>
<td>1.2.9</td>
<td>3.8.6</td>
<td>2.5.7</td>
<td>2.5.7</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>8.9.8</td>
<td>17.18.7</td>
<td>10.11.0</td>
<td>27.29.7</td>
<td>6.6.6</td>
<td>2.2.2</td>
<td>6.6.6</td>
<td>6.6.6</td>
</tr>
<tr>
<td>10 PU 1</td>
<td>No. of Units</td>
<td>-</td>
<td>9.19.6</td>
<td>4.8.7</td>
<td>10.21.1</td>
<td>7.15.2</td>
<td>4.8.7</td>
<td>2.4.3</td>
<td>6.13.0</td>
<td>4.8.7</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>-</td>
<td>19.17.6</td>
<td>7.6.5</td>
<td>20.18.5</td>
<td>16.14.8</td>
<td>8.7.4</td>
<td>4.3.7</td>
<td>19.17.6</td>
</tr>
<tr>
<td>11 PU 2</td>
<td>No. of Units</td>
<td>-</td>
<td>9.19.1</td>
<td>9.19.1</td>
<td>11.23.4</td>
<td>3.6.4</td>
<td>2.4.3</td>
<td>3.6.4</td>
<td>8.17.0</td>
<td>2.4.3</td>
</tr>
<tr>
<td></td>
<td>Total credits</td>
<td></td>
<td>-</td>
<td>21.20</td>
<td>15.14.3</td>
<td>26.24.8</td>
<td>6.5.7</td>
<td>5.4.8</td>
<td>7.6.7</td>
<td>15.14.3</td>
</tr>
</tbody>
</table>

(Percentages are written in bold)
Table 3 shows the relative number of units and respective credits units allocated to the different areas of chemistry by each of the university sampled for the study. There were courses in the areas of physical, inorganic, organic, analytical, and nuclear/quantum and Environmental, others are quantum/Nuclear, vocational, Industrial and students project requirement for graduation.

There are clear inconsistencies in the proportion of courses for different aspects of chemistry when compare with the NUC specifications. Examples are FU 1, SU 1, SU 2 and SU 3 where the total number of chemistry courses is 34, 42, 30 and 34 respectively compared with 51 of the NUC. However in the case of FU 1, there are courses with heavy credit units which were like combination of two or more equivalent courses in the NUC curriculum. The total credit unit of FU 1 is 104 while those of the other Universities with inadequate courses are 96, 68, 89 and 89 respectively.

A federal University (FU1) and the two private universities have no course designated as introductory, or general chemistry course as stipulated by NUC. The equivalent introductory courses are introduced to the student under their identified demarcation as physical, inorganic, organic or otherwise especially in FU 1. One Federal University (FU3) even had so much elaboration and very comprehensive introductory university chemistry, while the Universities of Technology FU4 and FU5 had scantly content of such equivalent courses. Universities can present Introductory chemistry courses in different ways especially when they have to give consideration to all other categories of undergraduates who need to have a foundation of their discipline in chemistry. In University of Michigan for example, for chemical science major students, premedical students and even engineering students, a comprehensive introductory chemistry course was packaged as Structure and Reactivity. The course is a perfect introductory organic chemistry [13].
Even as far back as 1927 till later in the 1940s[14] [15].; organic chemistry has served as first undergraduate chemistry course in many universities in the United Kingdom and United States of America. However, students still need holistic knowledge of chemistry.

A federal University FU1 and State University SU3 have no specific Electrochemistry course. The course content on statistical mechanism of SU1 I not given in detail. Also FU4 and FU5 have no specific course on Advanced Statistics. Three universities, SU2, PU1 and PU2 have no course on Main group elements; however, only PU1 has a course devoted to Water analysis.

The National University Commission has 19.4% of her courses on Organic Chemistry, while for other Universities except for FU 5 and PU 1; the universities have over 20% of the credits units of courses devoted to Organic Chemistry. The areas of Organic Chemistry and by extension applied Chemistry covered by the university varies from one university to another, only FU2 comply much with the NUC speculation. Also only FU2 has a course on Olefin Chemistry. Areas of Polymer Chemistry, Petro-chemical processes, Organic spectroscopy, food chemistry were all treated with varying degree of comprehensiveness across the universities. Many careers such as in the health sector, food processing industries extractive industries, chemistry and petro-chemical industries among others need to build their foundation in chemistry [16].

Many of these disciplines require background knowledge of Organic Chemistry especially to cope well in their practices in the enumerated careers. This thus demands, that chemistry undergraduate’s curriculum should be elaborate and cut across many areas. A lasting impact of education, more especially university education should go beyond mastering the subject matter, it should touch on the strength of life-coping and learning -to learn skill which would become an integral part of the learner and cause a transformation of behavior [10].
Only one course with a credit unit of three is obvious as an Environmental Chemistry course in the NUC guideline. FU 2, FU 3, FU 4, and FU 5, similarly SU1, and SU2 the Federal and states universities respectively have at least a course with different credit units on Environmental Chemistry. The private universities both have at least two courses on Environmental chemistry.

The courses under ‘Others’ are courses declared as seminar, industrial, natural products, food, and main group chemistry and/or projects. FU 4 has as many as 12 courses of this type, 22% of the total number of courses though with relatively low credit units. Next to this is FU1 with 10 courses but relatively heavier credit unit for the courses. Research project of six units is inclusive.

Research question 4: Does the structure and content of the undergraduate chemistry curriculum provide for development of vocational skill in the students? Table 3 shows that there are courses that could be regarded as vocational courses in all the universities. The NUC curriculum suggested 6 courses (11.8%) of chemistry courses being offered with sub-total credits of 17 (13.29% of the total chemistry courses. Only FU 5 has so many vocational courses that are even more than double the NUC specifications, probably because it is a university of technology while SU 3 has the minimum vocational chemistry course in this respect. Courses that could be regarded as vocational courses are treated sparingly in many of the universities.

The topics that are taught in many chemistry courses at undergraduate level are becoming too sacrosanct and not so important; rather there is need for more practical, feasible, and entrepreneurial development courses. This is one of the reasons why students who are enrolling in for postgraduate studies in chemistry are preferring Applied chemistry, Analytical chemistry, Industrial chemistry or Environmental chemistry to Physical, Inorganic or Organic chemistry. Amongst a total of 139 chemistry undergraduates who intend to go for postgraduate studies in
chemistry, only 27% of them were interested in Analytical chemistry, followed by Industrial chemistry and Organic chemistry in that order; 17.3% and 12.9% respectively [17].

These students feel that chances of employment and/or retention of job in manufacturing or production related organizations are high with specialization in analytical chemistry. Only a few students 4.3% that have confidence in their mathematical abilities could afford to go further in physical chemistry [17].

During a recent unofficial interaction with some chemistry undergraduates, Environmental chemistry seems to be the most preferred because what is more required now is sustainable development which can be found in maximum utilization of our Environment, since chemists are responsible for answering fundamental questions about the material world.

Chemistry as a science discipline can be described as the index of industrial development [2]. On the contrary, however, many undergraduates including those of chemistry department don’t really have a clear understanding of the prospect of the course they are studying. In a study involving 234 final year chemistry undergraduate, 68% of them could not decide what career they can pursue on graduation [16]. Considering the series of university curriculum review co-ordinated by the NUC arising from the June 2004 conference, Nigerian graduates are not expected to be unemployed. [18].

The National Association of Pre-Chancellors of Nigerian Universities declared in a committee of their third Biennial Seminar that many Nigerian Graduates are not employed because they are unemployable.[19] It was reported [18], that 60.8% of a cross-section of administrative personnel believes that Nigeria undergraduates are employable. Amongst reason for non-employability given by 39.14% of the administrators is inadequate exposure to job training schemes. [20]. There is a suggestion that for science graduates to be employable, generic skills
should be incorporated into their respective undergraduate curricula. [21] And these must be
generic skills that can support study in any discipline [22].

CONCLUSIONS

The curriculum of chemistry undergraduates in many Nigerian universities especially those
in the South Western part of the country, irrespective of the ownership, to a large extent expose
students to all aspects of chemistry. However, considering the centrality of chemistry to other
fields of study, to other sciences, health engineering and for sustainable technological
development, students need more application-oriented chemistry courses. There should be a good
number of elective chemistry courses that can cater for different areas of interest and students’
aspirations, with some flexibility in terms of requirements for graduation.

The counselling units of Students affairs need to continually organise vocational guidance
for students to make maximum benefits of the course they are pursuing with or without government
employment. There is need for uniform orientation of chemistry for all categories of students as
stipulated by a quality control body such as NUC and for these courses to be presented in less
abstract but in the way it can easily be applied to the different disciplines. Professional associations
of Chemistry such as the Chemical Society of Nigeria should take interest in what Universities
Teach and assist NUC in monitoring the quality of curriculum and graduates produced.

Again, going by the current global economic situation more especially in Nigeria where
graduate unemployment is growing at an alarming rate, a graduate of Chemistry should be able to
benefit from the vocational features of chemistry. At the undergraduates level more vocational
embedded courses should be included in the curriculum not only in university of technology but
in all the conventional universities as well. Industries that employ graduates of Chemistry should
also give feedback to Universities and Department about the training of their graduates. This will improve service delivery of Chemistry departments and employability of their graduates. Chemistry graduates can also be equipped enough to be self-reliant upon graduation.

REFERENCES

BIBLIOGRAPHY

• Federal University of Technology, Akure 2012: Chemistry Undergraduate Curriculum 2012-2014
• Joseph Ayo Babalola University (2012): Synopsis: Chemistry College of Science and Technology; School of Natural and Applied Sciences, Department of Chemistry
• Lagos State University (LASU) (2008): Students Handbook- Chemistry Department
• Obafemi Awolowo University (2014): Faculty of Science: Department of Chemistry 2014 Handbook.
INCIDENCE OF BIOGENIC AMINES IN FOODS
IMPLICATIONS FOR THE GAMBIA

Oladele OYELAKIN1* and Anthony ADJIVON1
1Chemistry Department, Division of Physical & Natural Sciences, University of The Gambia
*Corresponding Author: ooyelakin@utg.edu.gm

ABSTRACT
Amines are found in food. Biogenic amines are a class of amines, which result from decarboxylation. They are food quality indicators. Health-wise biogenic amines play positive roles and have adverse effects as well; they are a public health concern. Certain conditions make it possible for them to be produced. These could be controlled for a better and improved food quality. [African Journal of Chemical Education—AJCE 7(1), January 2017]
This feature article deals with a class of derivatives of ammonia called biogenic amines (BAs). These are found in food. A process known as amino acid decarboxylation is responsible for the synthesis of amines in foods. Decarboxylation has to do with the removal of the carboxylic acid group (-COOH) on the amino acid by enzymic reactions. Enzymes that take part in such reactions are known as decarboxylase enzymes. Amines, which are formed by this process, are known as biogenic amines, BAs.

BAs are toxic substances. They are responsible for many diseases in man and animals which are associated with the ingestion of food; food from plant and animal sources. The action of microbes on food during aging and storage results in the formation of biogenic amines. Some BAs which result from this process are: histamine, putrescine, cadaverine, tyramine, tryptamine, β-phenylethylamine, spermine and spermidine. Whenever they are produced, it is always as a mixture. There is a specificity to the production of these BAs: histamine is produced from histidine; cadaverine from lysine; putrescine from three amino acids: glutamine, arginine and agmatine. Depending on the food, some BAs occur in more quantity than others. Certain foods are known to contain more of some biogenic amines than others. Examples of foods which contain BAs include, fish, fish products, meat products, eggs, cheeses, fermented vegetables, soybean products, beers and wines. Conditions that lead to the production of the BAs: free amino acids, (proteinaceous foods), presence of micro-organisms that can decarboxylate amino acids. Mishandling of food, (during storage and processing) also leads to the production of BAs. Any food which ferments would produce BAs in the process of fermentation. Ironically, yoghurt is a fermented food, and it contains no biogenic amines. Conditions that favour the decarboxylation of amino acids must favor the production of the enzymes necessary for the reaction that would produce the BAs. However, it is possible to find high levels of histamine, a biogenic amine, in
foods before they begin to appear spoiled. So, the fact that food looks good does not mean that it is. According to a study carried out by Shalaby, even high temperature treatment, (heating) does not significantly reduce the amount of BAs found in foods that have been subjected to deliberate or accidental bacterial contamination. In other words, if food is bad, heating it does not make it edible [1, 2, 3].

BAs are also responsible for the typical and characteristic taste of mature foods. The taste of food becoming stale is due to BAs. BAs are responsible for food poisoning. The amount of BAs present in foods, fruits and vegetables provides an index for measuring food quality [3].

In the tropics fish are caught in temperatures more than 200C. These conditions make it easy for bacteria containing decarboxylase enzymes to act on fish if not refrigerated immediately. At temperatures between 00C and 50C bacterial growth ceases, however, enzymic activity continues to produce more BAs. In The Gambia, fish is widely consumed. At the sea side, one finds many fishermen displaying fish at temperatures over 200C; average temperatures range from 290C to 330C. Fish not sold is stored away in ice. When resold later, the quantity of BAs would have increased since enzymic activity would still have been continuing. In the market, women openly display chicken parts for sale at temperatures over 200C; usually under sunny conditions. This is noteworthy since no-one seems to do anything about this. Heating may not reduce the level of the BAs in these foods.

Importers play a major role in the wholesale and retail trade of poultry meat products. They usually operate cold chain facilities and market their products to retailers in cartons and to household consumers either in cartons, or whole chicken or in portions. Imported whole chicken or portions are sold by retail shops, supermarkets and street vendors. An important effect of the importation of poultry products has been an increase in health risks and incidents of food
poisoning, the Department of Livestock Services has documented instances wherein imported poultry products have been examined and found to grow fungi.

Consumption of food containing BAs leads to food poisoning, food borne disease, scombroid poisoning and tyramine toxicity, (results from cheese). Even poultry and farm animals can be poisoned from eating food containing BAs. This was according to a research carried out by C.A. den Brinker et al in 2003 [4]. In The Gambia what kinds of food do livestock farmers feed their animals? There is need for the appropriate professionals to look into these matters.

Certain conditions limit the production of BAs in foods. These include; pH, salt concentration and temperature. These could be exploited as a way of ensuring better storage conditions. Could fishmongers be made aware of the effect of BAs on what they sell? Tanji in The Gambia is a fishing village. Many men (men and women) in Tanji use generous amounts of salt when preserving fish; usually smoked fish.

Symptoms resulting from the consumption of large amounts of BAs in foods are: headache, nausea, hypo – or hypertension, cardiac palpitation and in severe cases, intracerebral haemorrhage and death [5, 6]. What percentage of reported illnesses in hospitals are due to the accumulation of BAs resulting from food consumption? If the population is educated on the effect of BAs, then may be the government would spend less on health care.

On the other hand, some BAs, are not that toxic; they play vital roles in the body. They are involved in growth of cells, tissues and organs. Their role in this respect is as cofactors in several biochemical reactions associated with cellular activities and proliferation. Other important roles include regulation of body temperature, stomach volume, stomach pH and brain activity. BAs are considered as very important food micro-components during periods of intensive tissue growth; infant gut maturation [1, 3]. In order for this biological function to be performed, the BAs must be
present in little quantity. Their use in this respect is strongly influenced by certain physiological conditions. A complication of this is that the presence of certain BAs in little quantity leads to the production of other BAs in large quantities. Further to this, the body also produces its own BAs. Different parts of the body contain different amounts of BAs. The amount produced depends on body metabolism.

Different researchers have analysed the amount of BAs present in certain foods in different countries. This is an area that could be looked into in The Gambia, especially with regard to the local foods and beverages. Perhaps better conditions of handling and processing could be discovered. There should be a ban on the open display of food in market places. This could lead to a better quality of food being consumed. Further to this, how much BAs are present in foods, which are imported into The Gambia? Are their levels safe for consumption?

REFERENCES
GUIDELINES FOR AUTHORS

The African Journal of Chemical Education (AJCE) is a biannual online journal of the Federation of African Societies of Chemistry (FASC). The primary focus of the content of AJCE is chemistry education in Africa. It, however, addresses chemistry education issues from any part of the world that have relevance for Africa. The type of contents may include, but not limited to, the following:

**RESEARCH PAPERS** reporting the results of original research. It is a peer-reviewed submission that deals with chemistry education at any level (primary, secondary, undergraduate, and postgraduate) and can address a specific content area, describe a new pedagogy or teaching method, or provide results from an innovation or from a formal research project.

**SHORT NOTES** containing the results of a limited investigation or a shorter submission, generally containing updates or extensions of a topic that has already been published.

**REVIEWS** presenting a thorough documentation of subjects of current interest in chemical education.

**LABORATORY EXPERIMENTS AND DEMONSTRATIONS** describing a novel experiment/demonstration, including instructions for students and the instructor and information about safety and hazards.

**SCIENTIFIC THEORIES** describing the scientific, historical and philosophical foundations of theories and their implications to chemical education.

**ACTIVITIES** describing a hands-on activity that can be done in the classroom or laboratory and/or as a take home project.

**INDIGENOUS KNOWLEDGE AND CHEMISTRY IN AFRICA** as a special feature that addresses the relationship between indigenous knowledge and chemistry in Africa. It could be in the form of an article, a note, an activity, commentary, etc.

**LETTER TO THE EDITOR**: A reader response to an editorial, research report or article that had been published previously. The short piece should contribute to or elicit discussion on the subject without overstepping professional courtesy.

All manuscripts must be written in English and be preferably organized under the following headings: a) **TITLE**, Author(s), Address(es), and **ABSTRACT** in the first page, b) **INTRODUCTION** reviewing literature related to the theme of the manuscript, stating the problem and purpose of the study, c) **METHODOLOGY/EXPERIMENTAL** including the design and procedures of the study, instruments used and issues related to the reliability and/or validity of the instruments, when applicable, d) **RESULTS AND DISCUSSION**, e) **REFERENCES** in which reference numbers appear in the text sequentially in brackets, each reference be given a separate reference number, et al and other notations like Ibid are avoided, and finally f) **ACKNOWLEDGEMENTS**.

When submitting a manuscript, please indicate where your manuscript best fits from the above list of categories of content type. All enquiries and manuscripts should be addressed to the Editor-in-Chief: email eic@faschem.org, PO Box 2305, Addis Ababa, Ethiopia.