THE NEED FOR A "BOLOGNA DECLARATION" PRONOUNCEMENT FOR AFRICA'S CHEMISTRY PROGRAMS AT TERTIARY LEVELS.

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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 a 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

Year	Semester	Courses				HEQSF credits	
1	1	A 1a	B 1a	C 1a	D 1a	15 x 4	60
	2	A 1b	B 1b	C 1b	D 1b	15 x 4	60
2	1	A 2a	B 2a	C 2a		20 x 3	60
	2	A 2b	B 2b	C 2b		20 x 3	60
3	1	A 3a		B 3a		30 x 2	60
	2	A 3b		B 3b		30 x 2	60

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]

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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

1. Labi, A. (2009). In Europe, Skeptics of New 3-Year Degrees Abound. The Chronicle of HigherEducation, June 11, 2009. http://chronicle.com/article/In-Europe-Skeptics-of-New-/44467/(accessed 2015-07-14).

2. DBE (Department of Basic Education) (2013). Technical Report on the National Senior Certificate Examination Results 2012. Pretoria: Department of Basic Education.
3. Council on Higher Education (2000). Towards a New Higher Education Landscape: Meeting the Equity, Quality and Social Development Imperatives of South Africa in the 21st Century.
4. Council on Higher Education (2013). A proposal for undergraduate curriculum reform in South Africa:The case for a flexible curriculum structure. Pretoria: Council on Higher Education: Report of the Task Team on Undergraduate Curriculum Structure.
5. Scott, I., Yeld, N. and Hendry, J. (2007). A case for improving teaching and learning in South African higher education. Higher Education Monitor No. 6, Pretoria:CHE. http://www.che.ac.za/documents/d000155/index.php (accessed 2015-07-12)
6. DHET (Department of Higher Education and Training) (2012a). Green Paper for Post-School Education and Training. Pretoria: Department of Higher Education and Training.
7. DHET (Department of Higher Education and Training) (2012b). Foundation Provision in Ministerially Approved Programmes. 15 May 2012. Pretoria: Department of Higher Education and Training.
8. Council on Higher Education (2004). Criteria for Programme Accreditation. Pretoria: CHE: Higher Education Quality Committee.
9. Wilfred F. Van Gunstern (2016). Going for a PhD: Joys and Pitfalls, Helv.Chim.Acta, 99, 1-5.