LEVEL OF BASIC SCIENCE AS AN INDICATOR OF A NATION'S RELEVANCE AND COMPETITIVENESS

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ABSTRACT
Educators should leave behind the simple role as disseminators of content and embrace a new paradigm as cultivators of curiosity and inquiry. This requires lots of fun to enjoy the teaching process to make the children’s seeds to grow. The whole essence of education is to get people to learn and Teachers are the life - blood of education and are to facilitate learning and achievement. Most teachers give no motivation, no spark of imagination or curiosity. Teachers must leave their students with their brain expanded with knowledge and questions of curiosity. Curiosity comes first because like magnets it draws the teachers’ imagination thus pushing students to ask why? If we are to inspire curiosity in our students, we must inspire curiosity in ourselves.

INTRODUCTION
I bring you fraternal greetings from the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana in the West African Sub-Region.
I wish to also thank the Conference Organising /Planning Committee of the University of South Africa, Pretoria, for inviting me as one of the Plenary Speakers for this conference.
I sincerely recognize that members here gathered are all experienced and are used to delivering addresses and lectures. Without doubt, it is an honour for me to be invited to address such an august gathering of scientists and science educators on this occasion.
I think it is only fair to warn you that very little that I am about to say to you on the chosen topic will be new to you. In order not to irritate you unduly, I have wherever possible and appropriate, resorted to quotations if the familiar idea, has been more happily expressed by another, than it is possible for me to do.
After I had accepted your invitation, I took a second and a closer look at the Conference Theme and was wondering to myself what challenges there are, that cut across the West African sub-region that may be peculiar and at the same time, may mirror those of the other sub-regions in Africa.
My first thought was for me as a teacher in the University, which perhaps may be the first teaser was, “what are challenges associated with first and foremost, the teaching of mathematics, science and technology to young Africans who yearn for formal education”. So the first idea was to do a quick scan through the various levels, ie., primary, junior and senior high schools and the
tertiary/higher educational institutions (Colleges of Education, Polytechnics and universities etc.;).

Secondly, based on the mode of instructions, “how are these young men and women able to surmount the various hurdles as they criss-cross the different levels of the educational ladder”; how are they assessed and what is the quality assurance of the Examination Body?

At the tertiary level, what are the challenges, especially regarding the quality of candidates eventually enrolled, into various disciplines in mathematics, science and technology; and finally, the training of science graduates some of who eventually go back to the lower levels to teach our young lads and lasses in the sciences.

Science education in Africa, as in other post-industrial countries, is in a state of crisis. Government, industry and educators use the language of crisis alike to describe the diminishing proportion of students in the post-compulsory years who are undertaking science-related studies, particularly in the physical sciences. In itself this might not be such an issue, except that this flight from science is occurring in societies that are in increasing need of science and technology-based professionals to carry the nation into a technologically driven future. It is the pipeline into this pool of expertise that seems in danger of drying up. The concern is thus largely economic, but the issue is wider than this, and encompasses the need to maintain a citizenry that is literate in and well disposed towards science.

The crisis has other dimensions, namely the shortage of skilled science professionals in the workplace and the shift in momentum of science-based development to developing countries, considerable evidence of student disenchantment with school science in the middle years, and a growing concern with a current and looming shortage of qualified teachers of science.

There are enough significant cracks appearing in the edifice to demonstrate beyond doubt that we are in the midst of a science crisis that is showing no signs of diminishing. Further, there is circumstantial evidence that the problem lies in part in a mismatch between the nature of the science curriculum, and the societal trends.

**Main aspects of the crisis in science education**

There are four main elements to the crisis in science education:

- evidence of students developing increasingly negative attitudes to science over the secondary school years
- decreasing participation in post-compulsory science subjects, especially the ‘enabling’ sciences of physics and chemistry, and higher mathematics
- a shortage of science-qualified people in the skilled workforce
- a shortage of qualified science teachers.

Of course these four aspects are closely linked. The shortage of qualified science teachers will impact on the quality of science classroom practice, and hence the enjoyment and learning of science by students, and this in turn will lead to a drop in numbers taking up science, and going
into science teaching. Arguably, we are in a downwards spiral which will almost certainly need to be addressed at a number of points if it is to be arrested.

**Student attitudes to science**

There have been concerns both locally, and internationally, about the increasingly negative response to science across Years 7–10. A number of studies over the last two decades have shown a general decline in students’ interest and enjoyment of science across the compulsory secondary school years, with a particularly sharp decline across the primary to secondary school transition (e.g. Adams, Doig, & Rosier, 1991; Goodrum et al., 2001). This decline in interest in science in the early years of secondary school is particularly of concern, since it is in these years that attitudes to the pursuit of science subjects and careers are formed (Speering & Rennie, 1996).

This is consistent with the views of Aikenhead (2006) who argues that there is abundant evidence that traditional school science is not meeting the needs of students, and that curricula with the characteristics he identifies with humanistic science are of more interest. He argues that for many students, especially Indigenous students, coming to appreciate science requires an identity shift whereby students come to consider themselves as science-friendly: ‘to learn science meaningfully is identity work’ (p. 117).

**Student participation in post-compulsory science**

A major aspect of the crisis in science education, and the aspect causing most direct governmental concern, is the drop in proportional numbers of students undertaking post-compulsory science courses, especially in the physical sciences and advanced mathematics. A number of speakers at international conferences have emphasized the magnitude of this problem of diminishing numbers of students entering university science-related courses (e.g. Masters, 2006; Osborne, 2006) at a time when the demand for science and technology expertise is growing.

This problem of diminishing numbers in science is occurring against a background of concern that post-industrial societies need to increase involvement in science and technology-related innovation and enterprise, if they are to remain competitive in a global environment.

Within the science community itself there is increasing alarm at the declining number of students opting to undertake science studies at the tertiary level.

Thus, the decline in the physical sciences is now becoming well publicized beyond government policy circles.

These dramatic drops in student involvement in post-compulsory physical science courses are of considerable concern to governments, since they prefigure a decline in a country’s ability to support technology and science-based innovation strategies that are fundamental to the economic well-being of post-industrial nations. A number of high level reports have pointed to the current and increasing shortage of science-trained professionals. For instance, the European Commission
The European Commission report (HLG, 2004) also focused on science education as the major underlying problem determining the supply of scientists. It argued that science education needed to change from an exclusive pursuit of subject matter expertise, to align it with a concern for the general educational development of the student. Their view was that school science should better link with real science practice, and align itself more effectively with the needs and interests of young people. The European Commission Group (HLG, 2004) emphasized the need to avoid elitist policies in science, striking a balance that promotes scientific excellence. It found that countries that appear to do well in terms of scientific literacy among young people and numbers of people employed as scientists tend to have policies aimed at increasing the overall performance of all schoolchildren.

In tracing the extent and nature of the crisis in science education, we see that there is clear evidence that the curriculum and classroom practice is failing to excite the interest of many if not most young people at a time when science is a driving force behind so many developments and issues in contemporary society. We see also that the main reasons behind this, at least from the students’ perspective, are understood. This decline in interest clearly contributes to a decline in participation in post-compulsory science, particularly physical science, and this is seen to have considerable implications for the economic wellbeing of post-industrial societies. There is another aspect that needs pointing out, involving a feedback loop. With decreasing student interest leading to decreasing participation in university level science, we have decreasing numbers of teachers coming into the system and a looming shortfall in qualified science teachers, particularly in the physical sciences. This will arguably make it more difficult to provide innovative and interesting science experiences in schools. We thus find ourselves in the midst of a downward spiral of engagement with science.

THE IMPORTANCE OF SCIENCE IN OUR SCHOOLS

We must support a system, which more fully engages our youth in science and technology. But how should this system be designed? What is really important about science in our schools? Some of the issues believed to be important in school science:

- Science education shouldn’t be prescriptive – it is about the ‘spark of excitement’ that stems from discovery
- Open-ended tasks and relevance are vital – students need to understand the world around them and make rational decisions on important issues
- Teacher confidence and professional development is just as important as the students’ learning materials.

We need to re-energize science. Unfortunately, secondary school and university students will not continue to fill our science classes just because we, as teachers, are passionate about our subject matter. We need to provide challenging units of inquiry to our students.
Scientific research has broadened from an individual-oriented approach to team-based work and collaboration with other researchers and industry. Collaborative science is essential if we are to address national impact and global problems such as climate change. A different skills set is needed in today’s scientists. We can no longer focus on a niche area. Collaboration is now the norm. We are all living in a connected world.

School science education is operating in a world where students ‘connect’ to students thousands of kilometers away in real time through instant messaging and they can escape to virtual internet worlds. Traditional science education is not fruitful in such an environment. Our best teachers are already making use of the new connections technology affords.

Every day we are faced with unfamiliar tasks and required to make decisions in unfamiliar contexts. Students will become more effective citizens by being able to locate, analyse and critique information to form their own opinions rather than being able to provide the atomic number of an element such as lead.

What should school science look like?

Interestingly, scientists believed the school curriculum held an outdated and discipline-bound view of science. They felt the focus should be on engaging young people, not on developing future scientists. I agree that we should not begin with a focus on recruiting, but on providing all students with opportunities to engage with science.

Science can be the bridge to understanding and engaging with many of these issues. Building a culture of interest in science will enable Africans to cope with a future that will be very much dependent on science and technology.

Students are naturally curious and love investigating. Let’s capture their imagination as the best teachers do by offering students flexibility in letting them explore ideas through investigation.

Science by Doing aims to actively engage science students in Years 7 to 10 by encouraging them to investigate science. It works on the principle that ‘doing’ leads to understanding and excitement.

Curriculum is nothing without expert teachers to coordinate the learning process. I am always amazed at how our best teachers engage and challenge all students in their classroom in some way. Such teachers link the science concepts to the world of their students, who can catch and hold those concepts, because the learning has become useful.

It is particularly important that Year 11 and 12 students have opportunities to link with industry, to discover possible career paths in science.

I think it’s so important for scientists in research laboratories, and for businesses and industry, to become involved at the school level. We need partnerships to be part of the ‘mainstream’ delivery of science.

Upgrading knowledge of Science Teachers

It is an unfortunate fact that many science teachers do not have enough opportunity to upgrade their science knowledge and to be introduced to new teaching modes.
The demands on teachers are great. To re-invigorate the science curriculum, to make a new ‘mainstream’, places even more demands on our teachers. Our teachers will need much support – professional development incorporating both resources and training. Teachers need time to become involved in professional learning communities, in schools and in their regions. Teachers are the experts and teachers will lead change in our schools and make it happen, only if they understand, believe in and champion the necessary changes.

I believe teachers need the skills and confidence to engage and excite children in their quest for new levels of knowledge and understanding of their world.

The key question we must return to is: ‘What are the skills our young people need in their lives?’

Generic ‘learning to learn’ skills are important; however, in a future increasingly driven by science and technology, we must also engage students in the issues that surround them. We must challenge our young people to think.

We must continue to support our teachers with ‘real’ professional development, not just resources. We must raise the profile of our teachers and encourage young people to consider teaching as a career.

**ASSESSING LEARNING ACHIEVEMENT**

Recently in Ghana (2007), the pre-tertiary education curriculum has undergone significant revision with a view towards eliminating the weaknesses associated with the structure and content of earlier education reforms. Its main objective is to make pre-tertiary education responsive to the challenges of education in the Twenty-first century and to also ensure that all learners get maximum benefit from the system. The philosophy, which guided the review, is the creation of a well-balanced (intellectually, spiritually, emotionally and physically) individual who has the requisite knowledge, skills, values and aptitudes for self-actualization and for the socio-economic and political transformation of the nation. Therefore the curriculum has been structured to reflect the national development goals of poverty alleviation and wealth creation. The demands of other pressing socio-economic goals and the present and future educational needs of the country were also considered in the review. The current objectives of the pre-tertiary education curriculum are to:

- emphasize active learning rather than passive listening by students;
- emphasize intellectual competencies and skills rather than subject teaching;
- promote the development and application of minimum standards of learning in all curriculum;
- promote the inter-consecutiveness of the different levels of the education ladder;
- inculcate skills and aptitudes for lifelong learning;
- strengthen literacy and numeracy at the basic level;
- create a parallel structure for academic programmes at senior high school level;
- promote a shift to science, technical and vocational education and training;
- formalize apprenticeship training;
- encourage competency-based training;
• link education to the world of work.

The 2007 revised pre-tertiary curriculum therefore puts greater emphasis on critical and scientific thinking as pre-conditions for developing the new type of Ghanaian who will become a problem-solver and be able to perform effectively in society. The revised curriculum emphasizes the acquisition of higher-level thinking skills (profile dimensions) involving the ability to analyze issues, make good quality judgments and generate solutions to problems in the classroom and in the society. This forms the basis for teaching-learning and assessment in schools, enabling the teacher to place emphasis on the various dimensions (i.e. knowledge and understanding, application, analysis, synthesis and evaluation).

Furthermore, the revised syllabuses emphasize participatory and problem-solving pedagogy and as much as possible, it de-emphasizes didactic pedagogy and rote learning approaches. Under the participatory approach, teachers are encouraged to use a mix of teaching methods within a lesson to ensure that the needs and expectations of every child are met.

The Ghana Education Service (GES) has evolved various models of evaluating the performance of pupils and students at all educational levels in the country, as well as that of teachers and lecturers.

At the basic and second cycle levels, there is a system of continuous assessments by which the actual classroom students’ performance is assessed and computed at the end of every school term. The GES has also developed a teacher’s self-appraisal instrument to measure the performance of serving teachers in basic schools.

Criterion referenced testing (CRT) is a test administered to 5% of primary grade 6 pupils in the country to assess the skills attained in English and mathematics at this level. The result is analyzed to give teachers the opportunity to carry out remedial exercises as well as make amends in cases of poor performance. Schools all over the country are randomly picked for this test. Results showed that pupils from public schools did not do as well as those in private schools. However, public schools have improved their performance in English and mathematics since the last test in 1997. The percentage of pupils scoring above the mastery levels of 60% in English and 55% in mathematics has also been improving over the seven-year period. Gender differences persist in mathematics, but there is no difference in performance in English.

The West African Examination Council, Ghana National Office conducts the terminal examinations for all pupils and students at the pre-tertiary levels of education. The examinations of the Council also serve as selection tests for progression from one level to the other in the country’s educational structure up to the tertiary level, where the results of the Council’s examinations are used for direct entry into tertiary institutions.

WEST AFRICAN EXAMINATIONS COUNCIL (WAEC)

In West Africa, the body responsible for the administration and supervision of most public examinations is the West African Examinations Council. The Council is a non-profit making
organization with its Headquarters in Accra, Ghana. It was established in 1952 following an ordinance passed by the Gold Coast Legislative Assembly in December 1951 (WAEC Ordinance No. 40). The establishment of the Council was the result of a report of a committee chaired by Dr. G. B. Jeffrey, (FRS) of the London University Institute of Education. Other ordinances were later passed in Nigeria, Sierra Leone and the Gambia. Liberia became its fifth member in 1974.

The Ordinances,

*Charged the Council with determining the examinations required in the public interest in West Africa and empowered it to conduct such examinations and to award certificates, provided that the certificates did not represent a lower standard of attainment than equivalent certificates of examining authorities in the United Kingdom.*

In effect, therefore, right from its inception, the Council was charged to conduct its affairs with the highest possible international standards and quality. Initially it conducted local basic level examinations such as the Common Entrance Examination to Secondary Schools, and the Standard Seven/Middle School Leaving Certificate. It also conducted on behalf of the Cambridge Local Examination Syndicate, the Cambridge School and Higher School Certificate Examinations for Secondary Schools.

In June 1960, the Cambridge Examination was replaced with the West African School Certificate while the Higher School Certificate was replaced in 1962 with the London GCE Advanced Level Examination. The Advanced Level Examination was also taken over fully by WAEC in 1963/64. The first Registrar was Kenneth Humphries, whose signature on certificates was fully recognized all over the world as a mark of the highest world-class standard and quality education.

The West African Examinations Council conducts both international and national/local examinations in all its member countries. These include the various secondary school leaving certificate examinations, primary/basic school certificate examinations, technical school leaving certificates in some member countries, and also conducts certain examinations in collaboration with other local and international examining bodies. The national examinations are developed for, and restricted to the specific member countries to reflect their local education policies, needs and aspirations while the international examinations are developed for candidates in all the member countries.

From a modest figure of about 3000 candidates for examinations at all levels throughout the country in the 1950s, numbers have grown to hundreds of thousands, while the number of subjects taken by each candidate has also grown. Currently, in Ghana, over 300,000 candidates take the BECE each year, in ten subjects. The WASSCE involves 120,000 to 150,000 candidates taking seven or eight subjects. The private candidates examination in November/December, which used to involve relatively few candidates who wish to improve their grades to enable them to gain admission to the universities and other tertiary institutions, has now grown to become as big as, or even bigger than the main April/May examination, involving between 150,000 and 180,000 candidates. Nigeria deals with five to ten times this number of candidates, while Liberia,
Sierra Leone and the Gambia deal with numbers much smaller than those of Nigeria and Ghana, but growing rapidly, especially after the civil wars in Liberia and Sierra Leone.

At 61 WAEC has gained an international stature and recognition for excellence in the quality of the educational standard that WAEC certificates represent. The high quality of the performance of many generations of West African students in polytechnics, universities and other higher institutions in Europe and America, indeed throughout the world, have borne testimony to the credibility of WAEC certificates.

Let us take a cursory look at the output of the teaching and learning of mathematics and sciences in High Schools in the English speaking West African members of the West African Examinations Council as presented in the 2013 annual report of the Council.
Performance of candidates in Mathematics and Science in the West African Secondary School Certificate Examinations (WASSCE)

Figure 1 Statistics on performance for the May/June 2012 WASSCE Ghana

Candidates exhibited varied abilities in their performance in the core subjects. 87.50% of the candidates passed at Grade C6 and better in Social Studies, 68.40% in English Language, 56.86% in Integrated Science and 49.90% in Mathematics (Core).

The best performance of 75.10% cumulative pass at Grade C6 and better was in Mathematics (Elective). Generally, the performance of candidates in the science subjects was encouraging with the worst, 58.00% in Biology. The female candidates performed better than their male counterparts in Mathematics (Elective) and Physics. This may partly be the spin offs from the annual Mathematics and Science Clinics for Girls, usually done by the Ministry of Environment and Science.

Figure 2 Statistics on performance for the May/June 2012 WASSCE Nigeria
In 2012, the performance of the candidates in science and other related subjects was very impressive. In General Mathematics, 50.58% of the candidates that sat the examination had grade 6 and above. So also did they in Physics (68.74%), Further Mathematics (51.92%), Chemistry (43.13%) and Biology (35.66%).
Figure 3 Statistics on performance for the May/June 2012 WASSCE Sierra Leone

In Sierra Leone, a total of one thousand one hundred and ninety-one (1,191) 2.09% candidates obtained credit and above in five subjects including English Language and Mathematics. Included in the figure are six hundred and seventy-six (676) males and five hundred and fifteen (515) females. On the other hand, four thousand one hundred and seventy-seven (4,177) (7.32%) candidates made up of two thousand three hundred and eight (2,383) males and one thousand seven hundred and ninety-four (1,794) females obtained at least credit in any five subjects. Female candidates performed better in five (Further Mathematics, Core Mathematics, Biology, Chemistry and Engineering Science, whilst their male counterparts outperformed them in Agricultural Science, Health Science, Science Core and Physics.
Results of the May/June 2012 WASSCE indicated that three hundred and ninety-four (394) candidates i.e., 5.02% obtained the minimum of five credits passes which included English Language and Mathematics. At the national level 5.70% of male candidates attained the pass level, while 4.23% of female candidates passed.
The performance of candidates on credit basis for the May 2012 Liberia Senior High School Certificate Examination was not encouraging. Besides Biology, Chemistry and English Language, which had more than 1% of the candidates obtaining credits, all the other six subjects recorded less than 1% of the candidates obtaining credit in the examination.

**Figure 5 Statistics on performance for the May/June 2012 LSHSCE Liberia**

The performance of candidates on credit basis for the May 2012 Liberia Senior High School Certificate Examination was not encouraging. Besides Biology, Chemistry and English Language, which had more than 1% of the candidates obtaining credits, all the other six subjects recorded less than 1% of the candidates obtaining credit in the examination.
Figure 6 Three-year (2009, 2011, 2012) performance statistics for the general science option Ghana

The performance of candidates for all the subjects in the General Science option was quite good in 2011 and 2012, compared to 2009. For Mathematics (Elective) there was significant improvement in the performance of candidates in 2012. Chemistry consistently recorded a reduction in failure over the period, but the rise in percentage failure in Biology in 2012 diet of the examination compared to that for 2011 after the decline in that for 2009 is worrying.
Figure 7 Three-year (2010-2012) performance statistics for the general science option Nigeria

Biology, Chemistry and Hausa recorded a steady decline in candidates’ performance at credit level during the three-year period (2010 – 2012).

Figure 8 Three-year (2010-2012) performance statistics for the general science option Sierra Leone

The three year period shows a fluctuating trend.
In 2012 the performance of candidates at credit level (A1-C6) improved over that of 2011 in the four subjects. It is also worthy of note that there is a persistent trend of improvement in performance by percentage of candidates passing at credit level in Biology and Physics.

**Figure 9 Three-year (2010-2012) performance statistics for the general science option the Gambia**
As a Chemistry teacher my humble observation is the fact that as a subject the performance of Chemistry has not been too encouraging. In the same vein the performances in the other Science subjects are not too different, which should be of much concern to Science Educators. The reasons perhaps may not be far fetched.

Part of the reasons may be hinged on the fact that High School Teachers also tend to depend too much on textbooks, which texts are most of the time incomprehensible to students because of what Tyler describes as the “tyranny of precision”. Communication of science has become the cult of “seriousness” and this undermines their confidence, leading them to offer a significantly more closed and less stimulating experience (Woolnough 1994).

A minimum skills and knowledge requirement for 16 may be 18 year olds has been the starting point for the development of frameworks as this is the age at which compulsory formal science education ceases in many countries.

Figure 10. Three-year (2010-2012) performance statistics for the general science option Liberia percentage obtaining grades (A1-C6)
UNDERGRADUATE STUDIES

Standards for Chemistry
Do we need an international standard for chemistry education in order to raise the world’s basic literacy and competence in chemistry? It is a question to ponder. No country wants to be marginalized, and as we ponder the future one thing is clear: the world is becoming more interdependent with outcomes of one country having a sharp impact on the outcomes of other countries. In order to establish a good quality of life for global citizens, I believe raising the basic knowledge and skills in chemistry that an individual possesses might be one of the most powerful strategies that we can pursue. International chemistry education standards might offer a possible avenue for reaching this goal (Chiu & Duit 2011).

In considering international standards for chemistry education, we have to also consider the values, expectations as well as limitations of each country and then find the common core literacy for all global citizens. There are key questions for science education in some countries that are not issues at all in the educational systems of Western Countries. Therefore, how to find the balance between global and national emergence requires some wisdom on the part of our educational leaders.

Traditional science teaching leaves little room for doing anything but moving predigested information from textbooks to testing. There are few to no safeguards to examine whether actual learning takes place, unless one presumes that correct responses to examination questions necessarily indicate student understanding.

The chemistry curriculum is influenced by the accreditation criteria in some jurisdictions and the vertical nature of the traditional course structure requires that students take courses that emphasize fundamental facts and skills before proceeding to the next level. Publishers compete with very similar textbook products leaving relatively few practical options for instructions to adopt different selections/arrangements of chemistry topics. The constraints of teaching a content-driven course that serves as a prerequisite for dozens of other courses, combined with the propensity for most instructors to teach in the way they were taught, leads to incremental change in curricular content and instructional method.

Most students taking chemistry do not plan to pursue a career in chemistry. They take chemistry because those courses are pre-requisites for degrees in fields of interests, medical sciences, engineering, pharmacy or nursing for instance. Hence lack of incentives is a profound obstacle to learning. On the other hand, chemistry contains an abundant amount of abstract concepts, which necessitates significant time and effort commitments from the students.

The contrast between the low inputs and high demands results in unsatisfactory performance on students’ side and frustration on the instructor’s side.

Although the motivation enhancement in chemistry career demands national efforts in terms of promoting science and technology increasing job opportunities, improving salary dynamics etc., a student’s interest is another motive that is not justifiable from an economic perspective.
Chemistry instructors may also improve students’ learning by inspiring students’ interest. The question is that “is chemistry really interesting?” Ironically, the answer is only “yes” to a limited number of chemists but not to general public due to adoption of tedious teaching methods in chemistry education. Presentation is the heart of the teaching process. The best way of getting students excited in chemistry is by presenting it in a dynamic manner with lots of fun.

GRADUATE EDUCATION & RESEARCH

Teaching must be research – informed
Teaching involves a dynamic interplay between the curriculum (often defined externally by Governments), the pedagogy (how teachers teach and the resources they use) and assessment (how curriculum objectives are assessed). Although this should represent an integrated system, this is not always the case and often assessment is the tail that wags the dog and determines how curriculum is interpreted and taught. There should be coherence between the learning outcomes, and the design of the assessment instruments.

The principal goal of education is to create (people) who are capable of doing things, not simply of repeating what other generations have done – people who are creative, invective and discover. The second goal of education is to form minds, which can be critical, can verify, and not accept everything they are offered. Jean Piaget (1964)

International scientific publication ranking by country is very insightful: http://www.scimagojr.com/countryrank.php

The scientific enterprise is not cheap and nations, which have not wished it to become obsolete, but have invested in it, have been rewarded with relevance and competitiveness in our global world. This is because the enterprise provides the tools that enable practitioners (well trained scientist and technicians working in cutting-edge facilities) to rise up to the challenges of solving multiple problems that arise as a result of solving a problem. This is the stark reality of our human existence and those who have recognized and acknowledged this reality and used it to their advantage have maintained their competitiveness or become one, which is reflected in the rankings of scientific publications.

The famous C.N.R Rao puts it succinctly, “I compare a developing, especially the least developed, to a man standing on the banks of a river that has a width that increases everyday. There is no hope of ever constructing a bridge across the river because the other side of the river gets farther and farther away”.

The isolation of chemists in developing countries is therefore a factor to be noted. Even the best of them have difficulty in keeping abreast of their fields and them unaware of what is happening
elsewhere. It is not the ability in chemistry alone that matters, but it is also the availability of information on the spot.

How does one remain competent, let alone be competitive, in a poor developing country? In most of such countries, the number of scientists in any given area is small. One has to depend on friends elsewhere to have a meaningful dialogue about a scientific problem. It should not be surprising that the contribution of developing countries to world chemical research is rather small. Based on the number of countries and populations, developing countries should contribute at least 30 – 40 % to global chemical research. If we take out Brazil, China, India, and a few other countries, the remaining 100 or so countries contribute a very small fraction to world chemistry.

Currently, Brazil and India contribute around 3% each of the world’s publications whereas China and the USA contributed 12% and 18% respectively. China will soon surpass the US in the number of papers it publishes. The proportion of global citations is 30% for the USA and 4% for China. In chemistry, the number of citations per research paper is 6.86 for China and 6.96 for India compared with the world average of 11.19. It is notable that in many of these analyses, developing countries from Africa and other parts of the world are not even mentioned.

Can the developing countries afford not to invest in talent and infrastructure required for the scientific enterprise and demand results from its scientist that will enable them to be competitive in the world market and also be relevant in Africa Geopolitics in the coming decades?

CONCLUSIONS

In conclusion, it is pertinent to ponder over a few rather rhetoric questions:

• What is the caliber of students being trained to teach science at the JHS and SHS levels?
• Are we doing social engineering to attract the best of talents into the teaching of science at the JHS and SHS levels?
• How do we attract talent into science and technology Research and innovation?
• How do we retain talent after undergraduate studies?
• How do we attract trained Ph.D. talent from abroad into at least collaborative research and development in Ghana and for that matter our respective home countries?
• How do we help students who ordinarily are not at the top of the academic ladder, to become some of the best in Science in the world?

To find solutions to these lingering challenges, the following pillars of college success in science are proposed:

i. Empowering students to learn

• Get the children to love to learn by lighting the spark of curiosity in them, remembering that curiosity is the engine of achievement.
• Provide teachers and the resources needed.
• Need to strengthen Grade 12
• Encourage students to asking the right questions
• Students should be encouraged to work in groups and support each other-building a community of students
• People as Faculty should be willing to help students grow interest, because of large enrollment

ii. Redesigning courses
• Academic innovations
• Students are getting bored studying on their own - task of achievement

iii. The dominant factor in education appears to be more of Testing than learning. This is as a result of culture of compliance. Teaching and Education should involve:
• Awakening powers of imagination
• Individualizing learning
• Investing in professional development
• Devolving responsibility to the school level
• Remember education happens in the classroom and not in the legislative rooms
• Education is about people – a human system and not a mechanistic system

iv. Educators should leave behind the simple role as disseminators of content and embrace a new paradigm as cultivators of curiosity and inquiry. This requires lots of fun to enjoy the teaching process to make the children’s seeds to grow.
• Most teachers give no motivation, no spark of imagination or curiosity. Teachers must leave their students with their brain expanded with knowledge and questions of curiosity.
• Curiosity comes first because like magnets it draws the teachers’ imagination thus pushing students to ask why?
• If we are to inspire curiosity in our students, we must inspire curiosity in ourselves. How many teachers lost their curiosity for life and learning long ago?
• How might we inspire it in other adults and spark a renewed curiosity in teachers who lost the interest long ago?

v. Teacher Training and motivation
• The whole essence of education is to get people to learn and Teachers are the life blood of education and are to facilitate learning and achievement
• Environment for teachers to grow
• Pay teachers well
• Belief that all children are capable
• Innovations in pedagogy
• For high performing systems, invest in the systems
• Communication of science should be devoid of the cult of seriousness
• Science communication has become a tyranny of seriousness, thus scaring the students
• Internet sources which breakdown complex concepts into simple languages for the Grade 13

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