Björn Risch (Ed.)

Teaching Chemistry around the World

WAXMANN

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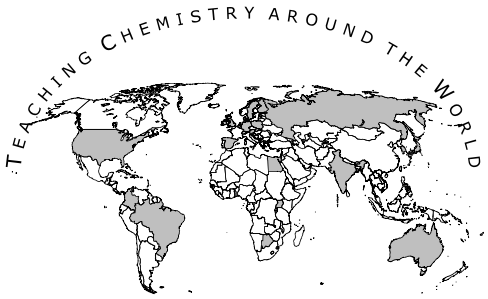
Table of Contents

Björn Risch

Introduction – TEACHING CHEMISTRY AROUND THE WORLD

Which school subject is usually considered unpopular, difficult and abstract?

The answer is easy: It is chemistry.



Certainly you must also know some people who turned their back on chemistry quite early and who now, having no idea of chemistry, consolidate the bad image of this subject and even pass it on to the next generation.

Yet in every country, chemistry – or rather, the knowledge of chemistry – is the foundation for innovation, scientific literacy and most notably problem solving in connection with sustainable development.

How do education systems handle this discrepancy between unpopularity and importance of this field? Is the urgently required basic scientific expertise being conveyed at all? Is there any opportunity for our pupils to become enthusiastic about scientific phenomena in chemistry at school?

The results of international comparative studies such as TIMSS and PISA show in an impressive way that different countries succeed to a greater or lesser degree. The considerable gaps between the scientific competences of pupils from different countries raise questions about their causes.

As teachers we often tend to expect other countries to teach chemistry much the same as we do, but educational systems differ widely. Studies of education provide reliable and up-to-date figures for the achievements in science of pupils in different countries. However, one important aspect is always missing: We do not know enough about how countries convey chemical knowledge to their pupils. Our surveys have shown that there is a worldwide need to illustrate and analyse the different concepts of chemical education, with the objective of disseminating the best practice.

At Bielefeld University we have started a project to analyse the approach to chemical education in different countries from all over the world: "TEACHING CHEMISTRY AROUND THE WORLD". These countries have been selected applying the following criteria:

(1) Popularity of and pupils' interest in the school subject chemistry,

(2) Importance of basic chemistry competence for the particular country,

(3) Results in international scientific tests and

(4) Reform and innovation strategies for chemistry teaching.

Rankings have been compiled according to these criteria and experts have been chosen in 30 countries. We have asked each country to describe their concept of chemical education (or natural science education, if science is taught as an integrated subject). Finally the following 25 countries have participated in this project:

Australia, Austria, Belgium, Botswana, Brazil, Colombia, Egypt, Finland, Germany, Hong Kong, India, Japan, the Netherlands, Poland, Republic of Korea, Republic of Ireland, Russia, Singapore, Spain, Sweden, Switzerland, Taiwan, Uganda, United Kingdom, United States of America

The resulting country studies are presented in this book. With reference to other studies of this kind [1] we initially do not aim for a systematic comparison. The individual country studies follow a consistent outline, though, and thus facilitate "skimming" particular chapters.

Guidelines: TEACHING CHEMISTRY AROUND THE WORLD

Basic structure of the educational system incl. some relevant statistical data (e.g. total number of pupils, teachers and schools)
Chemistry education (elementary sector, primary school, secondary level I/II)
Schedule for the natural sciences subjects/chemistry
Selection of topics
Sample exam test
Taking stock of the school system
Taking stock of current chemistry instruction
Training chemistry teachers at the university
Chemistry instruction – Innovative projects
Summary and prospects
References

The broad spectrum of country reports results in data of different structure and depth in each case. This is due to the particular authors' individual approach, especially specifications regarding statistical data and curricular contents differ distinctly in terms of detail, topicality and accessibility for outsiders.

What is this comparison aimed at?

Many education systems were conceived in the 19th century. Since then the world has changed fundamentally. Today it is a global platform, enabling people all over the world to exchange knowledge, to communicate, work and compete with each other. However, for the most part there is a lack of exchange when it comes to curricula. In contrast to many other fields, educational systems are difficult to reform. Traditions and cultural influences are too deep-rooted. Sticking to tried and tested practice is the problem here. A glance at other countries and their educational concepts is cast much too rarely. Educationally successful countries, e.g. Singapore, observe exactly which concepts prove to be successful in other countries and integrate them – where appropriate in a modified form – into their own educational systems. The following example illustrates this situation:

A study published in "Science" [2] has found that the proportion of high school students who passed a New York State Regents science exam was 10.1% higher if their science teachers had participated in the Columbia University Summer Research Program (CUSRP) than if they had not. Each summer the CUSRP teachers assemble one day a week for professional development activities. These include seminars, visits to science museums, demonstrations of science teaching and teaching materials, training in data-driven instruction and in transferring science concepts and technologies into the classroom, as well as teacher-led research presentations. The ease of implementing the CUSRP, its effectiveness, and individual and societal benefits have led to its adoption by Singapore's Ministry of Education.

In recent years the internationally oriented branch of research "Comparative Education" has been established to deal with general education questions. General comparative studies have raised the question in international educational discussions as to which features, and also which cultural and socio-economic background features, may be deemed responsible for the difference in effectiveness of education systems.

A presentation of chemistry teaching in so many different countries – comprised in one book – is unprecedented as yet. Hence the present work provides the opportunity to analyse differences as well as similarities between different countries with regard to the methods used to convey chemical contents and – where appropriate – to derive consequences for contemporary chemistry teaching.

The purpose of this investigation is to look out for "better" models and concepts in order to identify "best-practice-models". However, there is a danger of assuming that a successful educational model can simply be taken over by other countries to optimise their own teaching practices. This fallacy resulting from a naive adoption of the melioristic paradigm in educational-political discussions on reforms must be avoided.

The success of an educational system always depends on external influences such as political structure, social culture as well as demographic and other factors. A quotation from the English educational historian Michael E. Sadler shows that the concepts of foreign educational models cannot be implemented directly into another system of education in order to achieve similar success:

> "We cannot wander at pleasure among the educational systems of the world, like a child strolling through a garden, and pick off a flower from one bush and some leaves from another, and then expect that if we stick what we have gathered into the soil at home, we shall have a living plant" [3].

So in subsequent investigations the best concepts and aspects of chemistry teaching in the particular countries will be identified in order to examine how they can be transferred into one's own cultural and traditional context.

From the study of this book certain core themes emerge; two of these are introduced here as examples:

Entrance Examinations – selection of prospective chemistry teachers

It is striking that especially countries with successful education systems like Finland and Singapore rely on extensive selection procedures for students wanting to become chemistry teachers. This tendency is confirmed by many studies: As the most significant and costly resource in schools, teachers are central to school improvement efforts. Improving the efficiency and equity of schooling depends, to a large extent, on ensuring that competent people want to work as teachers [4].

Science vs. chemistry

One of the major differences between the science curricula is that some countries teach science as a single, general subject, while others teach the sciences as separate subjects (chemistry, biology and physics), usually beginning in the fifth, sixth, or seventh grades. A modern concept with respect to the combination of science subjects is currently being evaluated in the United Kingdom: Twenty First Century Science is a set of science courses developed to give all 14- to 16-year-olds a worthwhile and inspiring experience of science. There is a science course for all pupils. This is compulsory for all pupils whether or not they continue with science. In addition, young people can opt for one of two 'Additional Science' courses ('Additional Applied Science' and 'Additional Science'). Furthermore, Twenty-First Century Science offers the pupils the option to attend courses in biology, chemistry and physics, which supplement the science courses to provide a programme of separate sciences [5].

Further core themes arising from these country studies deal with topics such as curricular framework conditions, innovative projects in chemistry teaching, exams and exam papers, training curricula for prospective chemistry teachers etc. These core themes will be pursued by us in subsequent surveys.

This book may be seen as a contribution to make the structure of chemistry teaching in numerous countries more transparent and to facilitate communication between these countries. Especially in the case of the school subject chemistry, which is very unpopular on the one hand and occupies an exceptional position on the other hand – due to its relevance to jobs and everyday life and most notably due to its importance for innovation capacity and problem solving – we have to learn from each others' educational systems. I am convinced that we have taken an important step in this way and with the help of new ideas can teach chemistry so as to inspire our pupils.

References

[1] Hörner, W. (1996): Bildungssysteme in Europa – Überlegungen zu einer vergleichenden Betrachtung. In: Anweiler, O. (Hrsg.): Bildungssysteme in Europa. 4. neu überarbeitete und erweiterte Auflage. Weinheim: Beltz, p. 13-29.

[2] Silverstein, S. C. et al. (2009): Teachers' Participation in Research Programs Improves Their Students' Achievement in Science. In: Science, Vol. 326. no. 5951, pp. 440-442.

[3] Schriewer, J. (1982): Erziehung und Kultur. Zur Theorie und Methodik vergleichender Erziehungswissenschaft. In: Brinkmann, W. & Renner, K. (Hrsg.): Die Pädagogik und ihre Bereiche. Paderborn: Ferdinand Schöningh Verlag, p. 185-227.

[4] OECD, Teachers Matter (2005): Attracting, Developing and Retaining Effective Teachers.

[5] University of York Science Education Group (2006): Twenty First Century Science GCSE Chemistry Oxford: Oxford University Press.

AFRICA

Girija S. Singh and Jamil Ahmad

Botswana

Basic Structure of the Educational System

Botswana is a country of around 1.8 million people, situated in southern Africa and bordered by the Republic of South Africa, Namibia, Zambia and Zimbabwe. It is a stable, multiparty democracy. At the time of its independence from British domination in 1966, Botswana was one of the poorest countries of the world. Since independence its economy has been one of the world's fastest growing, benefiting from the development of its mineral resources, mainly diamonds, and prudent economic management. At present Botswana is classified as a middle income country. Education is given high priority by the government, in line with the country's Vision 2016, which is a manifesto for the country's development [1]. One of the key goals of the Vision for Botswana is to become "an educated and informed nation". The share set aside for education and skills development is 29.4% of the annual budget in 2009 [2]. The government is committed to providing access to education to the entire school-age population. Since 2001, every child has had access to primary education. Of those who successfully complete primary education, 98.5% enter junior secondary schools. The transition rate from the junior secondary to senior secondary schools is around 50.8%.

Formal schooling starts at the age of six [3], when a child enters primary school. Primary education is the joint responsibility of the ministry of education and local government, while secondary education is administered only by the ministry of education. After seven years of primary school, pupils join junior secondary schools, where they receive another three years of education. This is followed by a two-year study at senior secondary school. At present there are 206 junior sec-

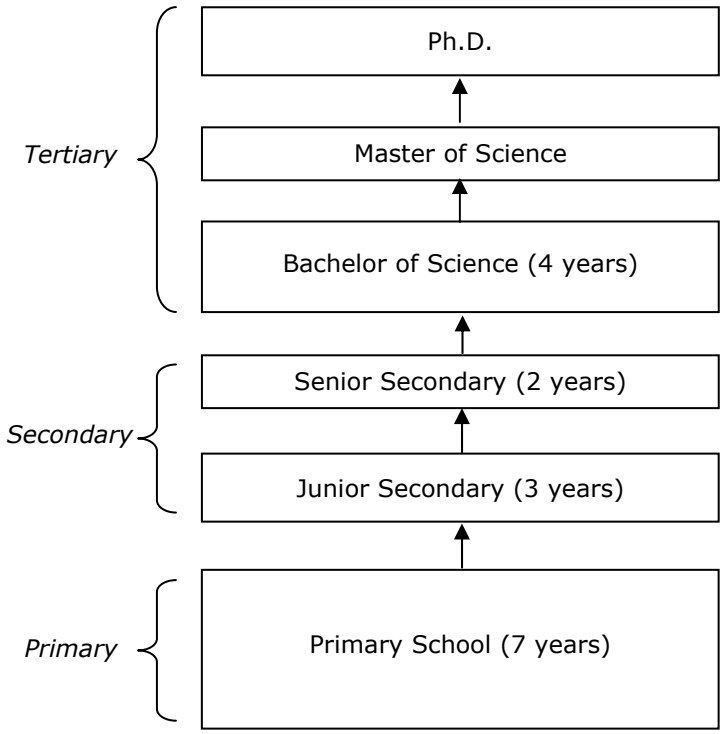


Figure 1: Education System in Botswana

ondary schools and 27 senior secondary schools (Table 1) [4]. A phased programme is underway to unify all the junior and senior secondary schools. A few schools have been merged so far. Some schools have double shifts in order to use the facilities in the schools to their fullest.

There is an examination at the end of each stage. The primary school leaving examination takes place after the seven-year study at primary school and is a diagnostic and placement examination to junior certificate. At the end of a further three-year study at junior secondary school, pupils take the Botswana Junior Certificate examination. This serves as a selection examination for senior secondary schools. Approximately half of the school population attends a further two years of secondary schooling leading to the award of the Botswana General Certificate of Education (BGCSE).

Pupils entering senior secondary schools take the BGCSE examination after two years of study. BGSCE replaced the Cambridge Overseas School Certificate (COSC) examination. The replacement process of COSC was started in 1993, carried out gradually in stages and was completed by 2002.The rationale of this replacement was to make the syllabus relevant to local conditions in Botswana and to adopt a subject-based approach to assessment with pupils' results being declared separately for each subject, instead of marks being declared as an aggregate of all the subjects, which was the case with COSC. In the COSC examinations and results, the pupils' strengths and weaknesses in individual subjects were not evident. It was pointed out, for example, that due to the importance given to English, the pupils' performance in English obscured their performance in other subjects [5]. Thus, pupils who may have done well in other subjects but who may not have performed well in English were put at a disadvantage. This is important, since the BGCSE is an entry qualification to university and to other tertiary education institutions.

Table 1: Total number of schools, pupils and teachers in Botswana (2006)

	Schools	Pupils	Teachers
Elementary	486	20,860	1,473
Primary	782	330,417	13,012
Secondary	274	162,767	11,553

Chemistry Education in Botswana

Elementary Sector (Pre-primary)

The children usually attend day care centres which play a major role in preparing them for primary school. The day care centres were opened in 1960 and were mostly in cities at that time. Nowadays, there is a significant increase in the number of such centres even in rural areas. More than half of these pre-primary schools are

owned by private individuals. The Early Childhood Care and Education (ECCE) programme was recognized as an essential method to prepare children for basic education in the Revised National Education Policy (RNEP), 1994 [4]. The Department of Primary Education in the Ministry of Education has been given the responsibility for monitoring and evaluating the programme as recommended by RNEP. It has been recommended that centres should be registered and supervised, curricula should be developed and teachers should be trained. An alarming increase in the number of untrained teachers in day care centres is causing great concern.

Primary Education

At lower primary school level (years 1 to 4) science is taught along with agriculture and home economics as part of environment science. The curriculum consists of four modules, namely, Our Surroundings, the Non-living Environment, the Living Environment and Health and Safety [6]. The aim is to help learners understand their environment and how they relate to it and also to help them to become aware of the inter-relationship between science, technology and society in everyday life.

At the upper primary school level (years 5 to 7) three hours per week are allocated to the study of science. The aim is to provide the learner with an understanding of the basic principles of science, and to develop critical thinking, problem solving and inquiry skills. The curriculum consists of eight modules: Science and Society, Nature and Universe, Matters and Energy, Force and Motion, Electricity and Magnetism, Health and Safety, Body Systems, and Sexual Reproductive Health [6].

The different states of matter, the difference between metals and non-metals and the physical properties of metals are taught. And the pupils learn about soluble and insoluble impurities in water.

The learners are introduced to chemistry specifically through an investigation of the properties of acids and bases. They identify acids and bases, and learn how to handle them with care.

Junior Secondary Schools

At junior secondary schools chemistry is taught as part of the integrated science syllabus. The aim of the three years of the junior secondary science programme is to develop the pupils' understanding of basic principles and concepts of science related to experienced situations in everyday life. The curriculum consists of ten modules: Scientific Methods and Precautions; Matter; Family, Life and Education; Water; Forces; Energy; Healthy Living; Our Environment; Communication and Science at Home [6]. The chemistry components included in these modules are shown in figure 2.

Chemistry at Junior Secondary (Secondary Level I)

Matter

Understanding Matter, States of Matter, Changes in States of Matter, Components of Air, Preparation, Properties and Uses of Oxygen and Carbon dioxide, Atoms, Elements, Mixture, Molecules and Compounds, Physical and Chemical Changes, Chemical Reactions, Acids and Bases and their Reactions, Metals and Non-Metals – Preparation, Properties and Uses, Reactions of Metals with Non-Metals

Water

Sources and Uses of Water, Dissolving, Hard and Soft Water, Purification

Science at Home

Common Household Chemicals, Simple Reactions of Household Chemicals

Figure 2: Chemistry concepts at Secondary Level I

Senior Secondary School

Subjects at senior secondary schools are divided into core and optional subjects. All the science subjects belong to the optional group of Sciences, which comprises the following three categories from which a pupil has to choose one:

– single science
– double science
– pure sciences

The single science option combines the three scientific subjects, Biology, Chemistry and Physics, in one examination paper. The syllabus for double science is more extensive than that for single science. Likewise in pure sciences more content is taught in each of the three subjects compared to the double science option. The examination for the pure sciences option comprises two or three theory papers depending on whether the pupils have opted for the core or for the extended syllabus, in addition to an examination on their practical work.

The aim of the chemistry syllabus as part of the pure sciences is to provide the pupils with the knowledge and understanding of concepts, laws, theories and principles of chemistry, handling information and solving problems as well as with methods of investigation and learning skills in chemistry. The topics covered are: atomic structure, the periodic table, chemical bonding, energy changes in chemical reactions, rates of reactions, redox reactions, equilibrium, electrolysis and acids, bases and salts (see figure 3) [6]. The objective of the practical part of the syllabus is to impart investigative and experimental skills. It aims to teach pupils to follow a sequence of instructions, to use appropriate techniques and apparatus to make observations and measurements and to interpret and evaluate data. The syllabus includes “promotion of indigenous chemistry and technology” as one of its objectives.

A feature of the syllabus is the division of its objectives into core and extended parts. All pupils follow the core specific objectives, while extended objectives are for those who are able to benefit from them. Examples of extended objectives are

to describe the lattice structure of sodium chloride, distinguish between inter/intra molecular forces and conduct an experiment to illustrate catalysis. Pupils pursuing core objectives can achieve a grade of C as maximum, while those pursuing extended ones may earn a grade of A*.

Chemistry at Senior Secondary (Secondary Level II)

Matter (4 weeks)

Particulate Nature of Matter, Atomic Structure, the Periodic Table, Chemical Bonding

Chemical Reactions (9 weeks)

Energy Changes, Rates of Reactions, Reversible Reactions, Redox Reactions, Electrolysis, Acids, Bases and Salts

Stoichiometry (8 weeks)

Chemical Formulas and Equations, The Mole, Chemical Calculations, Quantitative Analysis

Metals and Non-Metals (8 weeks)

Preparation of Metals, Extraction of Metals, Uses of Metals and Alloys, Non-Metals – Chlorine, Sulphur, Carbon and Carbonates, Nitrogen

Chemistry of the Environment (7 weeks)

Water, Air, Recycling, Sources of Energy

Carbon Chemistry (5 weeks)

Homologous Series, Alkanes, Alkenes, Alkanols, Alkanoic acids, Macromolecules, Synthetic Condensation Polymers, Natural Macromolecules

Figure 3: Chemistry concepts at Secondary Level II

Post Secondary School Education

The education system in Botswana has evolved from what was in place when the country gained its independence. As such it is broadly similar to the British school system, with one important difference. While a pupil needs the General Certificate of Education (GCE) A-level qualification to gain admission to a university in Britain, pupils in Botswana can apply for admission to the University of Botswana, which is the only degree-awarding university in the country so far, after passing their BGCSE. It is fully funded by the Government of Botswana. Recently some other private universities and colleges have come into existences that offer different kinds of diplomas, associate degrees and other degrees. The Government of Botswana has recently sanctioned the opening of a new university called the Botswana International University of Science and Technology (BIUST). This university may start enrolling students in 2011.

Students have to study at the University of Botswana for two years to qualify to be sent to a university abroad to study subjects such as medicine, chemical engineering or biotechnology.

In their first year at the University of Botswana, students take two general chemistry courses of four credits each. Four credits imply that they have three hours of

lecture contact time and one two-hour laboratory class in addition to one tutorial class a week. Principles of chemistry are taught in these courses. The courses have a prescribed textbook, usually similar to those used in many introductory level college courses in the United States. During the first semester, the syllabus focuses on atoms and molecules, the Periodic Table, chemical bonding, stoichiometry, redox reactions and the gas laws. In the second semester, organic chemistry, thermochemistry, aqueous solutions, chemical kinetics, equilibrium, acids and bases and solution equilibria are taught. The examinations comprise a balance between multiple-choice and open-ended questions. The questions test both concepts and the ability to solve numerical problems. The practical part of the course covers stoichiometry, simple organic reactions, calorimetry, acid-base titrations, determination of reaction kinetic parameters and solubility equilibria.

Sample Examination Questions for General Chemistry

1. Which one is the correct statement about the half-life of a first order reaction?

   (a) It takes two half-lives for all the reactant to convert to products.
   (b) The half-life is independent of temperature.
   (c) The half-life increases with increased initial concentration.
   (d) The half-life decreases with increased initial concentration.
   (e) All of the above statements are wrong.

2. Under constant volume conditions camphor (M = 153.1 g/mol) has a heat of combustion of 5903.6 kJ/mol. When 0.1204 g of camphor are burned in a bomb calorimeter, the temperature increases by 2.28 °C. What is the heat capacity of the calorimeter (in kJ/°C)?

   (a) 10.6
   (b) 140.5
   (c) 32.4
   (d) 2.04
   (e) 1.49

3. Example of a numerical question:

   A solution was prepared by dissolving 35.0 g of NH_3 in 75.0 g of water. The density of the resulting solution was 0.982 g/ml.

   (a) Calculate the mole fraction of NH_3 in the solution.
   (b) Calculate the molality of NH_3 in the solution.
   (c) Calculate the molarity of NH_3 in the solution.

Botswana's Performance in TIMSS

Botswana has achieved almost 100% enrolment in schools. The quality of education, however, remains a concern. The country wants to gauge the quality of its education and to compare it with other countries of the world, so it considers the Trends in Mathematics and Science Study (TIMSS) a good opportunity to monitor the quality of its education [6, 7]. So far Botswana has taken part in TIMSS in 2003 and 2007.

The results of 2007 showed a decline in Botswana's international ranking and in its performance compared to the results of 2003. In 2007 Botswana was the third lowest achiever, just above Ghana and Qatar, with a score of 355 compared to its score of 365 in 2003. As Botswana wants to be in league with high achieving nations rather than comparing itself with countries with a similar level of economic development, these results are not encouraging.

There has been no official public reaction by the education authorities to this decline between 2003 and 2007 or to the low ranking compared to most other countries. One factor responsible is perhaps the replacement of experienced expatriate teaching staff by newly trained national teachers, as a result of the localization policy of the government. However, no one would admit that publicly. In one year alone, 2005–2006, the number of expatriate teachers decreased by 21.4% [4]. Another factor could be the large increase in the enrolment of pupils between 2003 and 2007 without a corresponding increase in the physical or instructional facilities in schools.

There has been no public reaction from officials to this decline in the performance and, as far as we know, no publicly announced discussion has taken place to consider the poor performance. Botswana is a democratic and open country with a long tradition of consultation and matters such as this are openly and publicly discussed. The absence of any publicly expressed concern either from officials, or the press or from public figures is therefore surprising. Efforts to elicit reaction from the contact office for TIMSS in the country failed and emails to them went unanswered. The Botswana Examinations Council did, however, analyse the results and correlated the pupils' performance with their gender, whether they attended private or government schools, with the levels of education of the mother and father, with teacher's qualification, with the number of books in the pupil's home and even with the frequency of vandalism at the school [7].

Training Chemistry Teachers

At present chemistry teachers for junior and senior secondary schools are trained at the University of Botswana. There are essentially two routes to teacher training: pursuing the Bachelor of Education in Science, B.Ed (Sc.) or the Post-Graduate Diploma in Education (PGDE). The former is a four-year programme after com-

pleting BGCS at senior secondary school and it combines professional studies in science and education. The scientific content is studied together with regular chemistry major students, where the prospective teachers take a selection of courses offered by the university's department of chemistry and other departments. The courses include mathematics, general chemistry, a choice of physics or biology courses, courses on communication and study skills, basic computing skills and general education courses during their first year at the university. During the second year, prospective chemistry teachers study one further subject – either physics, biology or computer science – in addition to chemistry. In addition to these they are required to take core courses on education psychology, teaching methods in secondary school science, the historical, philosophical and sociological foundation of education and a practicum in secondary school science. In June and July during the winter break (Southern Hemisphere) they go to schools for teaching practice. They are assessed by instructors from the university on their performance in the teaching practice course.

During the third year at university, students only take chemistry content courses in addition to teaching method courses, which now deal with chemistry teaching only. Chemistry courses comprise a continuation of the traditional branches of chemistry: analytical, inorganic, organic and physical chemistry – both theory and laboratory courses. Education courses in the third year are courses on education for exceptional children, pedagogical content knowledge in school chemistry, practicum in school chemistry and research methods in mathematics and science education in addition to more teaching practice.

In their fourth and final year, the students have to take four chemistry courses in the department of chemistry. Moreover, they take courses on chemical pedagogy, two courses on ICT (information and communication technology) for science teachers, one course on contemporary issues in science education and one on history and philosophy of science. In addition to these the students are required to take electives from outside their department and general education courses to collect the required number of credits to graduate.

The other route to becoming a trained teacher is to study for the post-graduate Diploma in Education. This is a one-year course after graduation in a subject. The common core courses required to pass are, typically, psychology of learning, curriculum and instructions, information technology, guidance and counselling, evaluation, organization, and special education in addition to seven weeks of teaching practice. Also prospective chemistry teachers take a course on the theory and practice of science teaching and one on issues in secondary school teaching.

Summary and Prospects

Botswana is a middle income country, but the country's economy is heavily dependent on minerals, particularly on diamonds. Even though Botswana is the world's leading producer of diamonds by value, there is concern that the economy needs to be diversified. The current global financial crunch has underlined the seriousness of the problem for Botswana, whereby the income from the export of diamonds has fallen sharply. The policy of Botswana's government to spend such a large portion of its budget on education stems from the realization that an educated and well-informed population is the sine qua non for economic development.

The emphasis is now to improve the quality of the education. To achieve that, not only do the facilities in schools have to be improved, but also steps have to be taken to attract better students to a teaching career. At present, unfortunately, teaching is not a popular career choice for graduates. The conditions of service for teachers have to be made more attractive.

Chemistry is a central science. Its education and development has to play an important role in the development of any country which aspires to be an industrialized economy. Both the secondary and tertiary level curricula in Botswana are designed to cater for the need of the nation by keeping the employability of the students in mind. The curricula are periodically reviewed to maintain the international standards.

References

[1] http://www.vision2016.co.bw/ (Accessed on 15 April, 2009).

[2] http://www.gov.bw/2009BudgetSpeech.pdf (Accessed 15 April, 2009).

[3] Mahajan, D.S. and Singh, G.S. Chemistry/Khimiya (2005) Vol 14, pp 367-374. Also accessible at: http://khimiya.org/volume14/bg.abv.foreign.pdf (Accessed 15 April, 2009).

[4] Education Report 2006; Central Statistical Organization, Government of Botswana. http://www.cso.gov.bw.

[5] http://www.umalusi.org.za/ur/Conferences/AEAA/Utlwang%20A.PDF (Accessed 28 April, 2009).

[6] http://www.moe.gov.bw/ertd/news_and_events/index.html (Accessed 17 April, 2009).

[7] http://www.moe.gov.bw/ertd/downloads/TIMSS/timss_briefing_report.pdf (Accessed 17 April, 2009).

Rashed Mohammed

Egypt

Basic Structure of the Educational System

Egypt is a republic comprising 30 states. Of a population of nearly 75 million, approximately 16 million pupils attend schools at different stages. The Minister of Education is responsible for the entire education system. The classic form of instruction in Egypt begins at around 8:00 a.m. and ends at around 2:30 p.m. Each school period comprises 45 minutes of instruction.

Chemistry Education in Egypt

Kindergarten

Children between four and six years can attend kindergarten which is part of the public sector and many children at this age take advantage of the possibility. The learning activities at this stage focus on reading and writing skills as well as simple scientific and physical activities.

Primary Stage

As a rule, primary school comprises the age groups from six- to twelve-year-olds. There are approximately 1.7 million pupils in the Egyptian primary school system. Pupils at this stage acquire basic knowledge in reading, writing, calculating, scientific concepts and also in a foreign language (English). While in the first three years (grades 1-3) pupils study Arabic and Mathematics as the main subjects besides scientific and practical activities, pupils at grades four to six study Arabic, English, Mathematics, Science, Social Studies, ICT (information and communication technology) and Physical Education.

At the primary stage the core themes of Science and scientific activities are health and environmental education. The main concepts of the subject Science (comprising health education, environmental education, physics and chemistry) are change, the elements, environmental balance, materials, planets, the moon and stars.

At the end of primary stage pupils ...

– have learnt about scientific concepts such as the elements, heat, materials, magnets, electricity, environmental balance, environmental change.
– can classify materials according to their characteristics such as hardness, smell, colour, solubility.

– have discovered by experiment the characteristics of air and water.
– have discovered by experiment the states of materials.
– have discovered by experiment the characteristics of magnets.
– have discovered by experiment the physical characteristics of materials.

Chemistry is not taught as a separate subject at the primary stage, but is taught as part of the subject Science.

Preparatory Stage

As a rule, preparatory school comprises the age groups from twelve to fifteen years old. There are approximately 1.5 million pupils in the Egyptian preparatory school system. Pupils at preparatory stage study Arabic, English, Mathematics, Science and Social Studies as the main subjects.

The number of units and lessons of the main themes of Science at the preparatory stage is shown below:

Topic	year	semester	No. of units	No. of lessons
Sciences and the future	first	first	3	11
		second	2	7
You and sciences	second	first	3	12
		second	2	14
Sciences and human beings	third	first	3	10
		second	3	12

The themes and aims of Science at the preparatory stage are shown below:

Aims	Themes
• the pupil is able to explain the meaning of environmental balance and environmental change • the pupil knows methods to minimize air and water pollution • the pupil knows the meaning of: energy, electricity, electric field, density, material • the pupil knows the effect of viruses and bacteria on our health • the pupil acquires skills in performing chemical experiments accurately • the pupil is able to describe the electronic configuration • the pupil knows the different types of chemical reactions	Environment, water, soil, the sun, air, environmental balance, environmental change, cell, virus, bacteria, energy, density, material, machines, electricity, electric field, electric measurements, chemical reaction, chemical bonds

Chemistry is not taught as a separate subject at the preparatory stage, but is part of the subject Science.

The core themes of chemical education at the preparatory stage are:

– Elements
– Atom
– Electron
– Proton
– Neutron
– Component
– Ion
– Chemical Bonds
– Chemical Formations
– Chemical Equations
– Chemical Reactions
– Periodic Table

Secondary Stage

As a rule, secondary stage comprises the age groups from fifteen- to eighteen-year-olds. There are approximately 1.09 million pupils in the Egyptian secondary school system.

At the secondary stage Chemistry is taught as a separate subject. The themes and aims of Chemistry at the secondary stage are shown below:

Aims	Themes
• Pupils are able to distinguish between aliphatic and aromatic hydrocarbons with regard to their properties and reactions • Identify the process of electrolytic conductivity • Differentiate between electrophilic and nucleophilic substitution • Understand the concept of hybridization • Recognize the different types of reactions • Identify factors affecting chemical equilibrium • Understand the principles of ionic equilibrium in aqueous solutions • Gain knowledge about the nature of nuclear energy	• Nature of Chemical Science • Structure of Materials • The Modern Atomic Theory • Periodic Table • Chemical Bonds • Air Chemistry • Water Chemistry • The Solutions • Chemical Reactions • Chemical Equilibrium • Acids and Bases • Oxidation and Reduction • Organic Chemistry • Organic Products • Nuclear Energy

Training Chemistry Teachers at University

In Egypt the Faculty of Education is responsible for the chemistry teacher training. Students attend a chemistry teacher training programme.

Topic	Time
General Chemistry I	2 hours Lecture, 18 hours Lab
General Chemistry II	21 hours Lecture, 6 hours Lab
Organic Chemistry	20 hours Lecture, 6 hours Lab
Organic Chemistry I (Functional groups in organic Compounds I)	15 hours Lecture, 9 hours Lab
Organic Chemistry II (Functional groups in organic Compounds II)	21 hours Lecture, 6 hours Lab
Organic Chemistry III (Polynuclear and Heterocyclic Aromatic Compounds)	18 hours Lecture, 20 hours Lab
Organic Chemistry IV (Stereochemistry)	8 hours Lecture, 12 hours Lab
Organic Chemistry V (Biochemistry)	24 hours Lecture, 8 hours Lab
Inorganic Chemistry I (Main Groups and Transition Elements)	12 hours Lecture
Inorganic Chemistry II (Lanthanides and Actinides)	10 hours Lecture
Inorganic Chemistry III (Coordination Chemistry)	18 hours Lecture, 8 hours Lab
Inorganic Chemistry IV (Nuclear and Radiochemistry)	20 hours Lecture
Physical Chemistry I (Chemical Thermodynamics)	16 hours Lecture
Physical Chemistry II (Surface and Colloid Chemistry)	15 hours Lecture
Physical Chemistry III (Transport Processes and Phase Equilibria)	24 hours Lecture
Physical Chemistry IV (Chemical Kinetics and Catalysis)	9 hours Lecture, 9 hours Lab
Physical Chemistry V (Fundamentals of Quantum Chemistry)	6 hours Lecture, 4 hours Lab
Analytical Chemistry I	15 hours Lecture, 9 hours Lab
Analytical Chemistry II (Introduction to quantitative chemical analysis)	6 hours Lecture, 9 hours Lab
Environmental Chemistry	4 hours Lecture, 12 hours Lab

References

Alarish faculty of Education (2008): Program for Preparing Teachers of Chemistry.

Developmental Program for United Nations: Third World Forum (2005): Egypt Project 2020 (Project papers).

Education & Learning Minister (2006): Statistics of Classes Intensity in Primary Schools, Cairo, Public Management for Information & Computer.

Education & Learning Minister (2006): Statistics of Schools, Classes & Students in Kindergartens, Cairo, Public Management for Information & Computer.

Education & Learning Minister (2007): Science for Preparatory Stage, Cairo.

Education & Learning Minister (2007): Science for Primary Stage, Cairo.

Education & Learning Minister: Chemical For secondary Stage, Cairo.

Education & Learning Minister: Statistics of Learning 2001-2006, Cairo, Public Management for Information & Computer.

National Center for Educational Research & Development (2001): Learning Development, National Report of A. R. E.

National Center for Educational Research & Development & UNESCO (2003): National Plan of Learning to All 2002/2003–2015/2016.

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Uganda

Basic Structure of the Ugandan Educational System

Uganda is situated in the eastern part of the African continent. Blessed by nature, it has a mild climate with temperatures ranging from 16°C to 30°C all year and abundant rainfall of about 2000 millilitres per year. It has fresh water resources and equatorial forests. Currently Uganda's population is estimated at 28.3 million, with a population growth rate of about 3.2% per year [1]. The majority of the population (88%) lives in rural areas as subsistence farmers in a mainly agricultural economy. The country's literacy rate stands at about 65%. Uganda's education structure was modelled after the British education system, and until 1972, the public examinations were set and marked in Britain and the academic award after four years of secondary education was the "Cambridge School Certificate" [2]. Whereas Uganda still follows the British system and structure of education, all examinations are set and marked within the country and hence the certificates obtained are national certificates. Uganda's education system is highly formal, and non-formal education is only being developed. From Primary Four onwards the official medium of instruction is English; local languages are recommended for the lower classes.

The formal type of education, overseen by the Ministry of Education and Sports (MOES) has three major levels of education: primary; secondary, including Ordinary and Advanced level, and tertiary. Numbers are much larger at primary level, especially with increased advocacy and material support for basic education and the implementation of universal primary education since 1996. Access to higher education is narrow, although it has increased in recent years especially with the implementation of policies for its liberalization. The education system is thus pyramidal, as represented in figure 1 below. The figure includes the 7:4:2:3-5[1]-structure.

1 7:4:2:3-5 is 7 years of primary schooling, 4 years of Ordinary Level, 2 years of Advanced Level and 3 to 5 years of post-secondary level.

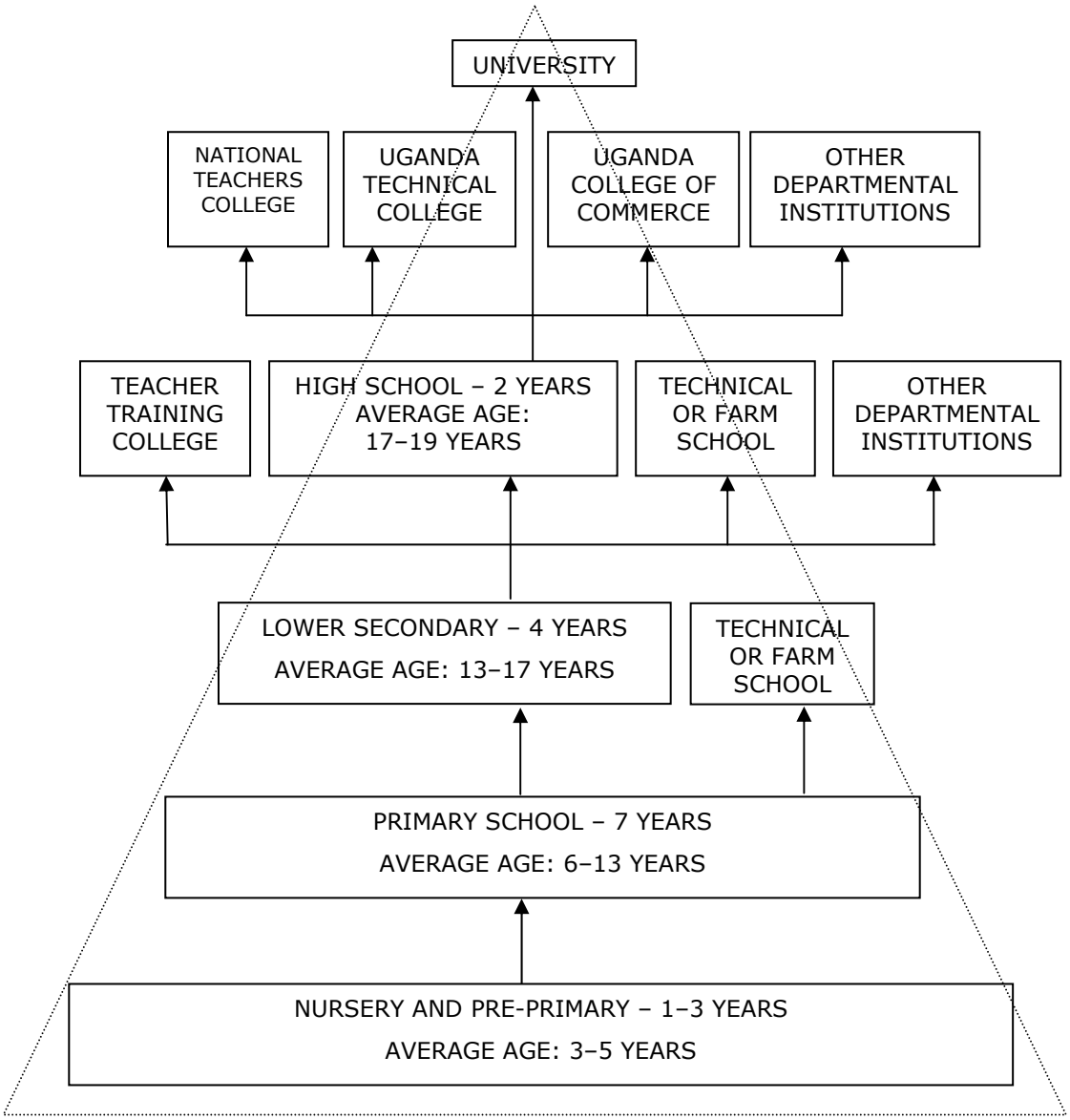

Figure 1: Structure of the 7:4:2:3-5 Education System in Uganda

Although the MOES is taking great interest in early childhood development and education, the only provision in this regard so far is nursery and pre-primary education, which is still purely private, provided by individuals and groups on a mainly commercial basis and mostly in urban areas. The MOES has three agencies.

– *National Curriculum Development Centre (NCDC)*, which is responsible for developing school curricula,
– *Uganda National Examinations Board (UNEB)*, which assesses pupils' academic performance,
– *Directorate of Education Standards Agency (DESA)*, charged with ensuring quality in education provision.

Nursery and Pre-primary

This level consists of nursery and pre-primary school. From age three to six, children attend nursery and pre-primary. Although nursery schooling is not compulsory, many primary schools, especially in urban centres, subject children to an interview before enrolling them in Primary One. Parents who aspire for their children to join good primary schools therefore find it necessary to enrol their children in nursery schools. Since the main objective of nursery schooling is to prepare children for primary level, the focus of its curriculum[2] is on aspects such as toilet training, socialization, listening, speaking, personal hygiene, drawing and painting, identification of colours, recognizing the letters of the alphabet, reading and writing, counting and simple mathematical operations like adding and subtracting. School normally starts at 8.00 a.m. and ends at 12.30 p.m.

Primary Level

Children generally start primary school at age six and complete the cycle at age thirteen. Currently, the seven years of schooling at primary level end with a final national examination known as the Primary Leaving Examination (PLE). By 2006, after 10 years' implementation of the Universal Primary education (UPE) programme, there were 17,807 schools[3] in the primary school sub-sector, with 7,362,938 pupils and 150,135 teachers [3].

The primary school curriculum consists of four compulsory subjects viz English, Mathematics, Science and Social Studies. In Social Studies, children study some aspects of geography, history and civic education and religious education, which includes Islam or Christian religious education. Science consists of elementary biology, mainly with some aspects of health science and nutrition; agriculture, with some aspects of physics, and a few chemistry concepts [4].

Primary Level [4]

- The world of living things
- Matter and energy
- Science in human activities and occupations
- Human health
- Our/The environment
- The human body
- The community
- The circulation system

Figure 2: Science Themes for Primary Six

2 An early childhood learning framework is now available, developed by the NCDC and approved by the MOES, but not all nursery schools know about it or use it.

3 In Uganda, there are both government aided (public) and private primary schools. In all the public schools, schooling is meant to be free of charge while in the private schools the reverse is true.