



The Dynamics of Curriculum Reforms in Botswana with Special Reference to Science Education

Modise Mosothwaneⁱ
University of Botswana
P/Bag 00702 Gaborone Botswana
mosothwm@mopipi.ub.bw

Abstract

This paper identifies changes that occurred in Botswana Science Education. The paper indicates that Botswana follows a centralized system of curriculum development and this approach facilitates the implementation of new curricula. The paper also describes models of curriculum development used in Botswana. Furthermore, the paper also identifies barriers to curriculum change and factors that influence changes in science curriculum. In conclusion, the paper suggests ways of improving science education in Botswana so that it is of high quality.

Keywords: Curriculum reforms, Science education, Curriculum, Curriculum change.

Reference to this paper should be made as follows:

Mosothwane, M. (2013). The Dynamics of Curriculum Reforms in Botswana with Special Reference to Science Education. *International Journal of Scientific Research in Education*, 6(4), 331-351. Retrieved [DATE] from <http://www.ij sre.com>.

INTRODUCTION

There is a commonly held perception by the general public that changes in the curriculum are for the better, because they bring in new ideas, new concepts and new research based instructional strategies. This perception needs to be investigated further to establish the extent to which it is also true in developing countries (Mosothwane, 1995). Developed countries have always given developing countries financial support but with attached strings forcing developing countries to change their curricula even when it is not necessary to do so. Hopkin (1996) argues that sometimes developing countries make changes in their education system not directly beneficial to them but because developed countries dictate to them how to spend money.

The driving force behind the reforms in science education was the launching of Sputnik into space by the Russians in 1957 which gave an impetus to curriculum reforms in science and mathematics education of developed countries (Martin, et al, 2008). Science curriculum projects in the Western countries mushroomed to counteract the Russian supremacy when they realized that they were behind the Russians in science and technology. Curricular changes in developed countries occurred in the 1960s on an unprecedented bringing in innovations in teaching such as discovery teaching method which was strongly advocated by Scottish Integrated Science Project (Waring, 1979; Harding, Kelly, & Nicodemus, 1976).

Botswana, a former British protectorate became independent in September, 1966, but continued using the British Education System so that its graduates are internationally recognized and are admitted into institutions of higher learning in other countries. A general concern was raised by the Western countries that their science and mathematics curricula were not preparing students for science and technology (Martin, et al, 2008). Consequently the Western countries changed their science and mathematics curricula to lay a strong foundation for science and technology. Developing countries too thought that by changing their science curricula, they would improve the quality of their education making it relevant and cost effective.

Botswana also changed its science and mathematics curricula to ensure that it is not left behind in technological developments and would not have a serious shortage of people with science related careers (Mosothwane, 1995). As Botswana changed its science curricula, it followed certain models.

Models of Curriculum Development in Botswana

A combination of various models of curriculum development has been used in Botswana to develop science curricula. These include:

- The Objectives based model. This model gave developers focus, guidance and direction. The model is scientific because it requires precision, accuracy and use of scientific steps.
- The Romantic/Progressivist Model. The model gained popularity in the 1960s as it calls for the integration of subjects and rejecting subject compartmentalization because in real life people solve problems using a combination of skills rather than one skill. Integrated Science came into being as a result of the romantic model.
- The Constructivist Model. This model asserts that knowledge is socially constructed by the cognizing subjects. Consequently, the model calls for the use of prior knowledge in teaching- learning. Our science curricula suggest that children should first be taught concepts that are related to their environment since this will help them learn science concepts meaningfully as they link new concepts with what they already know.
- The Participatory Model. This models calls for an interactive approach where stakeholders dialogue on things to be included or excluded from the curriculum. The model is subjective and process oriented, and calls for the interaction of various interested groups is important. The model is now gaining popularity in Botswana as more and more stakeholders begin to develop interest in curriculum development process. In science curriculum panels there are people from the health section, environmental sanitation and quite recently the community has been involved in teaching some concepts. The participatory model is said to have contributed to quality curricula since it includes ideas from all stakeholders.

CONCEPTUAL FRAMEWORK

The conceptual framework for this paper is based on socio-economic status and social change. Kahn (1990) asserts that curriculum reforms in Botswana were a result of socio-economic status. Just after attaining its independence, Botswana was classified as a poor underdeveloped country but, as the economy flourished due to the sale of minerals, Botswana began to develop needed technicians and other people with science

related careers without which there can be no development. Bernal (1965) concurs 'No society can do without the amount of science required for the working productive forces... Any state or class which does not, or cannot use science and develop it to the full is doomed in the present world to decay and destruction, (p.1236). Rantao (1984) also supported the use of science to develop a country's economy, 'The structure of our educational system falls too far behind the altering technological and production structure of our economy ... we need science to be successful' (p. 238). Botswana was forced to develop its science curricula to lay a foundation for those who aspire to study for science related careers. The sale of diamonds contributed to the development of science curricula.

Nganunu (1988) also agreed that changes in the curriculum were caused by social change in society and use of science and technology which Botswana aspired for.

Curriculum Change in Primary Science

The demand for technicians, electricians and road engineers compelled Botswana to introduce science in its primary school curriculum in 1969 (Republic of Botswana, 1973; Leburu & Rosser, 1980). It was thought that by introducing science in its primary schools, a foundation would be laid for studying science at the secondary level of education (Swartland, 1988).

Prior to 1969, Botswana offered Nature Study, Physiology and Hygiene and Health Education as its science curricula in primary schools (Mosothwane, 2011). The content topics of these subjects were basically biological sciences. Emphasis was preservation and conservation of the environment, rules of hygiene and first aid.

When science was introduced in primary schools, teachers were not prepared for it since concepts such as electricity, magnetism, sound, chemical and physical changes were new to them. Mantswe (2005), reported teachers were not oriented in the content of the new science curriculum and in how to teach it. No workshops were held for teachers and no teaching materials or resources were available to help teachers to prepare for science lessons. Serving teachers were never taught the physical sciences in their pre-service training in teacher preparatory institutions (Mosothwane, 1995). The new science curriculum advocated the use of discovery teaching or investigatory methods. These instructional strategies were very new to teachers and in addition teachers were not work-shopped in them. Serving teachers were used to exposition, yet they were expected to use investigation in teaching the new curriculum. Investigation or discovery teaching methods were reported to be highly effective in promoting understanding. Bruner (1961) asserts that discovery teaching helps learners to: (i) retain more information (ii) shift external rewards to internal satisfaction (iii) equip learners with problem solving skills (iv) learn how to learn independently. The method is based on the Chinese Adage 'I do and I understand.'

Constraints were met when the new primary science curriculum was introduced. Some concepts (e.g., Atomic Theory) were new to teachers and were well above their levels of understanding (Republic of Botswana, 1969). Nevertheless, the government went ahead with the implementation of the new science curriculum. This made teachers anxious, frustrated and helpless (Republic of Botswana, 1977).

The late President, Sir Seretse Khama appointed a National Commission on Education in 1975 to review the entire education system of Botswana. The report which was published in 1977 singled out primary science as being problematic and recommended it to be replaced by a new relevant primary science (Republic of Botswana, 1977). The Commission blamed lack of development in science and technology in Botswana on the type of science curriculum offered in primary schools.

The report indicated that the 1969 primary science curriculum was not taught properly because it was not examined at Primary School Leaving Examination (PSLE) and recommended that it be examined to force teachers to teach it seriously. The Commission recommended the development of a relevant science curriculum which would ensure that pupils apply science to real life situation.

It was thought that the 1969 primary science curriculum was imported from Britain because examples of sources of energy were from Britain

The National Commission on Education of 1977 recommended a relevant science curriculum because it will be meaningful to children. This recommendation led to the development of a new primary science curriculum which was implemented in 1982 (Republic of Botswana, 1982).

The 1982 primary science curriculum was different from that of 1969 in the following ways:

- Approach: the curriculum placed more emphasis on children's interest rather than treating children as if they were at the same level of intellectual development. Teachers were to start teaching children beginning with what is in their immediate environment.
- Objectives: unlike those of the 1969 primary science curriculum whose emphasis was on mastery of content, those of the 1982 primary science curriculum emphasized process skills (Republic of Botswana, 1982).
- Content: the content of the 1969 primary science curriculum was overloaded with advanced concepts while that of the 1982 primary science curriculum was user friendly.
- Teaching materials: textbooks for the 1982 primary science curriculum were available and were written by Botswana which was not the case with the 1969 primary science curriculum.

The 1982 primary science curriculum was the first science curriculum in Botswana to have concepts on family life and environmental education (Mosothwane, 1995). The science panel which developed the 1982 primary science curriculum thought that children would benefit from a more relevant to life curriculum. The panel believed that children learn better and enjoy learning when they are engaged in activities. In the 1969 primary science curriculum children were passive participants and learned science by memorization.

The 1982 primary science curriculum employed a variety of science process skills which aimed at promoting scientific attitudes while the 1969 primary science aimed at laying a strong science foundation for those who will proceed to junior secondary schools. The 1982 primary science curriculum used locally produced teaching materials.

The 1982 primary science curriculum coincided with UNESCO philosophy of Universal Primary Education (UPE) which stated that the scientific literacy of children in developing countries should be raised. UPE recognized that children were not one entity, they were different and consequently, the 1982 primary science curriculum catered for individual differences. At the time the 1982 primary science was being taught, government decided to introduce free education which was recommended by the National Commission on Education of 1977. Parliament approved free education bill which was introduced in 1986 (Republic of Botswana, 1986). This eliminated direct costs as constraints to access and consequently a large number of students enrolled for primary and junior secondary levels of education. The three year junior secondary education programme was also reduced to a two year programme. Both primary and junior secondary levels of education constituted the nine year basic education programme. As time goes on, there was however, a public concern about the quality of the nine year basic education programme. Primary science was described as weak by junior secondary school teachers since it did not prepare students for junior secondary school science programme (Kahn, 1988).

Junior secondary school science teachers reported that primary school pupils lacked knowledge of basic science concepts they were expected to have learned in primary schools. In addition, text books written for the 1982 primary science were considered to be of low standard. As a result, a primary science panel was established in 1989 to review the 1982 primary science and to develop two new primary science curricula, one for lower classes and the other for upper primary classes. The two curricula were implemented in 1992 and 1993 respectively (Republic of Botswana, 1992 & 1993).

The 1992 & 1993 primary science curricula were different from that of the 1982 in that they were organized in modules and under each module, process skills to be used for teaching science concepts were stated. The two primary science curricula had a research project in which pupils were to choose a scientific topic and to write a research report on it. However, the research reports were never written. At the same time, the nation became dissatisfied with the quality of the nine year basic education programme so much that

President Sir Ketumile Masire also appointed another National Commission on Education in 1992 to review Botswana's entire education system (Republic of Botswana, 1993).

The Report of the National Commission on Education was published in 1993, but a summary of its recommendations culminated into a policy paper called 'The Revised National Policy of Education of 1994' was published in 1994 (Republic of Botswana, 1994). This Policy document, recommended that lower primary science be replaced with Environmental Science to help children develop responsible environmental behaviors at a tender age. It was believed that children's environmental behaviors can easily be changed while they are still young. Environmental Science Curriculum was implemented in primary schools in 2002 (Republic of Botswana, 2002). Environmental Science is comprised of Agriculture, Home Economics and Science and called for the use of new teaching methods namely investigation and debate. These new methods were quite different from the normal exposition methods that teachers were familiar with. Concepts such as road safety, personal hygiene are now taught in standard one because they are critical to the life of the child.

The Revised National Policy on Education of 1994 also recommended that the 1993 Upper Primary Science be replaced by another Upper Primary Science Curriculum relevant to Botswana. The new Upper Primary Science Curriculum was implemented in 2005. This upper primary science has rigorous content topics that are to be taught by science specialists. The 2005 primary science calls for application of science to real life situations (Republic of Botswana, 2005).

Environmental Science and Upper Primary Science Curricula are currently in use in all government primary schools. Environmental science supports the view that knowledge is holistic and not compartmentalized. Human beings solve problems using a combination of skills and thoughts rather than one thought or skill. The aim of environmental science is to teach pupils how to maintain a quality environment and to develop responsible environmental behaviors at a tender age.

Upper primary Science is offered in standards 5, 6 & 7 (Republic of Botswana, 2005) and it is the first primary curriculum to include HIV/AIDS issues and environmental health in its content topics. The teaching of HIV/AIDS has been accepted as part of the normal science curriculum. The current upper primary science curriculum aims at promoting the scientific literacy of children and would lay a strong foundation for science and technology by 2016. Primary science specialists can identify misconceptions and emphasize use scientific language in their teaching. Changes also occurred in the junior secondary school science curriculum.

Curriculum Change in the Junior Secondary School Science

Prior to independence, Botswana had two science curricula at the junior secondary level of education, namely, Introductory Science Alternatives A & B. Introductory Science Alternative A was comprised of Biology, Chemistry and Physics (Makunga, 1980). The aim of Introductory Science Alternative A was to produce students with strong science background. Furthermore, the syllabus intended to introduce more useful chemistry concepts to lay a good foundation for school certificate work (Makunga, 1980).

Physics was the longest part of the syllabus because useful information fell under it (Makunga, 1980). Consequently physics was examined at greater length than the other two sections. Introductory Science Alternative B was biology and was specifically developed for private candidates. Since Introductory Science Alternative A required a practical examination, it was thought that a theoretical paper for private candidates will also test essential scientific knowledge. Although Introductory Science Alternative A was used in all junior secondary schools, those who taught it faced many problems such as: (i) lack of suitable textbooks for pupils, (ii) lack of experience to teach the syllabus (Makunga, 1980). Teachers complained that the syllabus was too long and practical work was not done well. There were also complaints that some concepts were too difficult and were not to be rushed because they formed an essential entry point to study science at school certificate Level (Makunga, 1980)

Makunga stated other problems that hindered the implementation of syllabus A. He contends "apparatus was not available. Teachers were ill-equipped to tackle the syllabus. There was no indication of

the depth to which topics were to be taken. This later became one of the reasons why teachers subsequently expressed dissatisfaction with the syllabus” (p. 54). Due to the decline in performance of students in Alternative A, the syllabus was reviewed in 1971 (Makunga, 1980). A large number of teachers expressed dissatisfaction with Alternative A and wanted it to be changed immediately. Teachers contended ‘change was not only necessary, but also overdue (p. 55).

In 1971, members of the Examination Council of Botswana, Lesotho and Swaziland agreed to replace syllabus A with a single science syllabus (Makunga, 1980). Science panel members of each country (Botswana, Lesotho & Swaziland) were to determine the scope and the content of the new science curriculum. The new science curriculum was called ‘Integrated Science’ and after the finalization of its scope and content, the science curriculum for the three countries was called ‘BOLESWA Integrated Science Syllabus’.

Integrated Science Curriculum

Integrated Science curriculum was introduced in junior secondary schools in 1974. Its aim was to make learning enjoyable and to promote positive attitudes. As the syllabus was being implemented, challenges and problems were met and these included: (1) shortage of teaching materials like books and worksheets. These had an impact on activities done in laboratories. Students had to share worksheets and this created a problem of who should take care of the materials before the start of the next lesson (2) Most teachers were not qualified to teach the new science curriculum (Makgothi, 1986).

Teachers were not trained in methods of teaching science concepts in an integrated manner during their pre-service training. Local teachers were trained in one subject at degree level. Biology teachers were trained in biology, so were chemistry and physics teachers. These teachers were confident and competent in their areas of specialization. (3) No thorough in-service training was held for teachers on how to teach integrated science. An in-service training was conducted in December, 1973, yet implementation was done in January, 1974. However, some members of national science panel got help from their Swaziland colleagues who introduced Integrated Science before Botswana and Lesotho (Makgothi, 1986). (4) Class size. Due to large number of students, laboratory exercises were often left incomplete. This interfered with laboratory set ups and denies students the individual help they could get from their teachers. In addition, when teachers explained the procedure for conducting laboratory exercises, the explanation could not reach all students.

Why Integrated Science

The perception that knowledge is holistic gained momentum in the 1960s. Supporters of this perception assert that some school subjects should be integrated into one discipline and be taught as one subject. This perception led to the development of integrated science comprised of physics, chemistry, biology, earth and environmental sciences.. Botswana wanted its students to see an interrelationship between different disciplines and consequently decided to teach science as a whole (Makgothi, 1986). The Senior Science Education officer contends ‘There is no doubt that in the early stages of child development, science should not be fragmented’ (Makunga, 1980; p. 52). Setidisho (1971) also agreed ‘It is at this early stage that pupils should see science as a whole and the interrelationship which exists between separate disciplines (p. 4).

Makunga (1980) advanced reasons for teaching science in an integrated way as follows:

- In the primary school, they have had only one teacher for a whole year at a time. In the secondary school, children meet different teachers for different subjects and as a result, they need readjustment to the new situation. So integrated Science should be taught by one teacher to help children to readjust.

- The first two years of secondary school should be considered a period of reorientation. If science is taught as three separate disciplines in the early stage, the time available for each teacher to assess his pupils would be inadequate.
- Pupils should see science as a whole and the interrelationship which exists between separate disciplines. It was considered that having a single Integrated Science syllabus would be easier to timetable.

Makunga also stated that three separate sciences taught by three different teachers would not lead to a 'proper understanding of science as a unity'. He stated that integration is achieved only where subject matter fell naturally together. One of the reasons why integration was adopted by educators was that it advocated child-centeredness rather than teacher-centeredness. In integrated science, pupils do activities that teach them what 'science is, and how a scientist works. Integrated science employed a variety of process skills to help pupils learn science with understanding. It uses guided discovery methods to develop knowledge and understanding. These methods helped students to get involved in the learning activities. Laboratory work was highly valued in integrated science, even though it had no practical examination (Makunga, 1980).

Curriculum Development in Integrated Science

Proposals for introducing Integrated Science in junior secondary schools were completed in 1971, and consequently a science curriculum development officer and a national science panel were appointed. The panel was composed of science education officer and science teachers (biology, chemistry and physics). Teachers in the panel were selected based on their teaching experience and their areas of specializations. In their meeting, the science curriculum development officer acted as the secretary of the panel. Makunga (1980) noted 'For the first time in the history of Botswana, teachers were to become directly involved in curriculum development' (p.62).

Originally, Botswana opted for an Innovation Project called the West Indian Science Innovation Project (WISCIP) but Scottish Integrated Science whose philosophy was active learning promotes understanding. Teachers were not adequately prepared for the introduction of Integrated Science in junior secondary schools since they attended a three weeks in-service course in December, 1973. Time to familiarize teachers with integrated science philosophy and its teaching methods was not enough. Materials for teaching Integrated Science were available because the Danish Government paid for them (Makunga, 1980).

Although BOLESWA Integrated Science's philosophy was to teach science concepts in an integrated manner, 'some science concepts stood out clearly on their own while other concepts lent themselves better to an integrated approach. For example, electricity stands out as a pure physics topic while detecting the environment involves a study of the sense organs and includes the physics of sound and light' (Makunga, 1980, p.67).

When the National Commission on Education of 1977 submitted its report, it recommended that junior secondary school programme be reduced from three years to two years; however, it took nine years for its recommendation to be implemented. It was implemented in 1986 and Botswana began to have a Nine Year Basic Education Programme. This led the junior secondary school science panel to develop the two year Integrated Science Syllabus

The Two Year Integrated Science Syllabus

The two year junior secondary school science was implemented in 1986. The aim of the two year junior secondary school programme was to expose students to scientific concepts in a social context (Ngununu, 1988). The curriculum catered for students who would join the world of work and those who would proceed to senior secondary schools. It was expected that students whose education ends at the nine year basic education programme would have a working knowledge of basic science concepts required for survival in

rural areas. Scientific concepts taught in the nine year basic education programme were considered adequate to help people improve agricultural production by using scientific methods (Makgothi, 1986).

Unlike the three year Integrated Science Syllabus which was composed of 15 units, the two years Integrated Science Syllabus was composed of 12. An analysis of the worksheets of the two year science syllabus suggests that it was overloaded with content so much that it forced teachers to rush over some concepts irrespective of children's understanding. The syllabus was too much examination oriented and this forced teachers to rush the syllabus to avoid a situation where their students would meet some concepts for the first time in the final examination. This caused the performance of students in the two year junior certificate science examination to decline (Kahn, 1988).

The Two Year Integrated science syllabus placed more emphasis on application of science concepts. For example, instead of acids, alkalis, hydrogen and salts which were in the three year Integrated Science, the Two Year Integrated Science treated the same topics as 'chemicals in the Household' (Makgothi, 1986). In addition, the syllabus showed how science concepts were linked to other subjects of the school curriculum. For example, population studies in Social Studies, Family Life Education in Home Economics, Religious and Moral Education. Most concepts in the syllabus were relevant to the needs of local people. The examples were relevant and appropriate to pupils of a wider range of abilities and were taught under simpler conditions.

The Two Year Science Curriculum taught pupils problem solving skills which they could apply to solve their local problems. Unlike the three year Integrated Science curriculum which had no optional worksheets, the two year science curriculum had optional worksheets. The core worksheets accommodated the needs of all children and gave instructions on 'what to do and what to write' while the optional worksheets backed up the core worksheets. The two year Integrated Science Syllabus advocated child centered methods. The curriculum document opined:

"The syllabus is a pupil centered with a large and essential component of practical work in a Laboratory or science room making maximum use of easily available low cost materials. It utilizes the discovery method to transfer useful skills and knowledge to the pupils and is structured around integrated themes and topics" (Republic of Botswana, 1986, p. 1).

Although the syllabus advocated discovery teaching methods, it was a problem for old teachers who were not trained for teaching Integrated Science. Consequently extensive in-service courses on how to teach science using discovery and cooperative teaching were conducted by the University of Botswana for such teachers (Kahn, 1987).

In-service science courses recommended demonstration as a method of instruction when there was a serious shortage of teaching materials. Demonstration can save children out of danger, can teach students how to handle an equipment properly, can help teachers show important changes, help the rest of the class understand a particular concept when a student explains it, can be used to develop communication skills and can help children develop self confidence in speaking before a crowd (Wolfinger, 1984)

However, teachers on in-service course were also shown limitations of demonstration such as denying students learn how to use and handle equipment, limiting students' ability to write reports, denying students to learn how to organize and present information, making teachers get frustrated when demonstration fails, children becoming restless or inattentive and visibility as a problem in large classes (Kahn, 1988)..

When the two year junior certificate programme was introduced in 1986, the enrolment of students went up because school fees were also abolished. More science teachers were also required so much that teachers from other disciplines were recruited to teach science. In some instances, unqualified teachers were called in to help (Kahn, 1988).

The two year integrated science curriculum faced many problems such as shortage of equipment and this forced teachers to lecture and to write notes for students. The shortage of equipment was a result of

ordering them from Britain and it took time for them to arrive and by the time they arrive, teachers had already covered some units. There were no local companies which could supply the equipment or materials. This situation was caused by the perception that locally produced equipment were of low quality and could promote misconceptions. Since there were many students who enrolled for the two year programme, there was a need to cater for mixed ability teaching (Makgothi, 1986). Workshops on mixed ability teaching were held for all junior secondary school teachers.

The public became dissatisfied with the two junior secondary programme that in 1992 Sir Ketumile Masire appointed a National Commission on Education to evaluate of the education system of Botswana.. The Commission solicited information from different organizations and people. The dissatisfaction expressed by the public included:

- Secondary pupils complete their junior secondary education programme (Form 2) often immature and below the minimum employment age.
- The two year junior secondary programme is too short for effective secondary level of education especially that there is wide ability range amongst pupils.
- The two year cycle is disruptive to the school community as half the pupils enters and the other half leaves each year
- There is high degree of public dissatisfaction with the programme concerning the quality of the nine year basic education programme (Republic of Botswana, 1993).
- The standard of achievement was questionable and the two year Junior Certificate was not accepted by employers and training institutions as equivalent to the former three year qualification. In the report, the commission argued that a Ten Year Basic Education programme would address the above problems. Employers also complained about the knowledge students had gained in the two year programme (Republic of Botswana, 1993).

Due to the above reasons, the three year junior secondary school programme was re-introduced in 1996 (Republic of Botswana, 1996), hence the development of the new junior certificate science curriculum.

The Three Year Junior Secondary School Science Curriculum

The Revised National Policy on Education of 1994 came into being as a result of the Report of the National Commission on Education of 1993. The Report recommended the re-introduction of the three year junior secondary education programme. The Parliament approved the recommendation and junior secondary school science panel was appointed. The three year science curriculum is divided into units called modules for example there is a module on earth science and contemporary issues (Republic of Botswana, 1996).

The development of this curriculum was based on the philosophy of constructivism as indicated in the preamble:

“In teaching the syllabus, it should be recognized that when children come to school they come not with blank minds, but with some knowledge, skills, attitudes and beliefs. Some of these experiences may become useful or inhibitive during the teaching/learning process, and so teachers have to be aware of these earlier experiences to more effectively communicate understanding through recognizing individual abilities, interests and needs” (Republic of Botswana, 1996, p. i).

The junior secondary school science panel stated their position as follows:

“The science syllabus is designed to cater for students who will proceed to senior secondary education or vocational training and those who will leave of the end of Form 3 to the world of work” (Republic of Botswana, 1996, p. i).

The curriculum does not have practical work or worksheets like the previous Integrated Science Curricula. Although this aspect has been left out, it is important for teaching problems solving skills which would enhance understanding of scientific concepts. Having realized that the 1996 junior secondary science did not dovetail well with the BGCSE science syllabi, it was decided to introduce a new junior secondary science curriculum whose content would address some of the 21st century social issues and consequently, the 2010 junior secondary school science curriculum was developed.

The 2010 Junior Secondary School Science Curriculum

The junior secondary school science panel wanted to have a quality science curriculum. which is technology friendly and which match will match with the BGCSE science programme.

An analysis of the syllabus suggests that it dovetails well with the BGCSE science programme. This will give students a strong science background for studying senior secondary science programme. Furthermore, senior secondary school teachers will not blame junior secondary school science teachers for lack of students’ basic science knowledge (Republic of Botswana, 2010).

Senior Secondary School Science Curricula

Prior to its independence from Britain in 1966, Botswana senior secondary school science curricula consisted of Health Science, Biology and General Science (Nganunu & Clegg, 1980). These science curricula were examined by Cambridge University at Ordinary Level.. General Science consisted of biology, chemistry and physics. Health Science approached health from a pure scientific point of view. This approach was however, considered inappropriate and as a result Health Science was replaced by Human and Social Biology in 1973 which approached health from both a scientific and social point of view (Nganunu & Clegg, 1980). Botswana secondary school biology panel thought that both the scientific and social approaches were the best ways to address health issues. The two subjects were also examined by Cambridge University. General Science has been offered at the senior secondary school level of education for a long time even in 1962. This was because General Science did not have a practical examination which would require many chemicals and equipment. Furthermore, General Science had well written textbooks based on Cambridge Ordinary Level..

General Science content was not strong as that of Physical Science which was introduced in 1972(Nganunu &Clegg, 1980). This was evident in 1974 when the Faculty of Science of the then University of Botswana, Lesotho and Swaziland accepted only Grade A or 1P into the degree of Bachelor of Science but admitted students with Grade C or 6P in physical science into the degree of Bachelor of Science (Kgoroba, 2008) Physical Science had a practical examination paper composed of physics and chemistry sections. The examination tested skills such as observation, recording and measurement.

Biology is the oldest as records show that it was taught in Botswana secondary school science curricula even in the 1930s (Nganunu & Clegg, 1980). The British thought that biology was a useful subject for Batswana who were predominantly agriculturalists and its teaching would improve food production because of use scientific methods in farming. The British were also concerned with the health of local people and those who passed biology trained as health professionals

The other pure science subject taught in Botswana senior secondary schools was Physics. Just after gaining its independence, Botswana had a high demand for technicians, electricians, engineers, mechanics, etc. It was thought that physics would prepare people for such careers. Physics was also required for

operating most home appliances. Another pure science offered in Botswana senior secondary schools was chemistry which prepared students for careers such as pharmacists, water technicians, chemical engineering, plumbers, etc.

Both physics and chemistry equipped students with skills and competencies required in science related careers. Records show that the pure sciences, physics and chemistry were introduced in senior secondary schools in 1972 (Nganunu & Clegg, 1980). Nganunu & Clegg (1980) reported a lot of problems met in teaching these subjects such as:

- Getting teachers with the right qualifications and experiences because in the 1960s, very few students in Botswana graduated in the sciences and very few majored in physics and chemistry as the subjects were newly introduced. As a result, there was a desperate shortage of students who majored in physics and chemistry since those few who did well in these science subjects were absorbed into the market. Because of the serious shortage of physics and chemistry teachers, the Ministry of Education hired unqualified teachers to teach these subjects. This had a negative impact on students' performance.
- Lack of prepared materials for Forms IV and Vs: There were no worksheets or guides for laboratory work. There were also no prepared tests to guide teachers on how the questions were set in the final Cambridge Ordinary Level Examination. Teachers spent a lot of time asking Cambridge to send them past examination papers. Teachers also spent more time preparing for laboratory exercises to help students develop scientific skills. An improvement was made by having experienced teachers from Britain who ordered appropriate books. The books are still in use even today. The physics textbook for ordinary level by Abbott and the chemistry by Holderness helped to improve the performance of students in physics and chemistry.
- Inadequate Laboratory and equipment: Some questions in the Cambridge Examination required the use of equipment, for example students were asked to draw waveforms as they appear on an oscilloscope screen in 1977 yet oscilloscopes were made available only in 1979 (Nganunu & Clegg, 1980). There was also a problem of no storage spaces in the laboratories for chemicals making teachers to leave out experiments which were to use such chemicals. However, the demand for science graduates forced the government to use more money to build laboratories in secondary schools in an H shape with preparation rooms. These laboratories included dark rooms and smaller store rooms. The availability of finance made it possible to equip most senior secondary schools and this enabled students to do practical examinations in the sciences.
- Size of classes: There were too many students in a class such that conducting experiments became problematic and as a result, demonstration was predominantly used and this denied students the opportunity to practice 'hands on minds on activities'. Teachers were also unable to give students the help they needed. When students worked in groups of four or five, only two conducted the experiment while the other two were doing nothing. This affected the results in the sciences at senior secondary level of education.
- Background of students: Since General Science was taught in the 1960s, the majority of students were from rural areas where household gadgets operated by electricity were not available. The situation was made worse by the fact that parents of most students were not in a position to explain scientific facts to students. The problem was compounded by the fact that equipment and materials used in science were new to students. This also contributed to a large number of students failing science. The pass rate at Ordinary level was between 30% and 40%. As a result, a large number of students failed physical science and the pure sciences (Nganunu & Clegg, 1980).

The performance was poor in science for the following reasons:

- Poor primary school science background: Complaints have been raised that primary science was inadequate to lay a strong foundation for secondary science. Lack of equipment and teaching materials (books) contributed to primary school children's' poor science background.
- Lack of psychological preparation for the examination: Science teachers did not prepare students for examination and as a result, children's hopes were not raised. Since students had low hopes and it turned out that their performance was lowered.
- There was a shortage of qualified personnel to back up teachers: There were very few science education officers to give advice and to inspect science subjects in schools. Consequently, teachers did not get the help they needed. University science education lecturers did not run/ conduct in-service workshops to boost teacher confidence. There were no people in homes who had a working knowledge of science who could help students with home-works.
- Science was studied in a foreign language: In Botswana, science subjects are studied in English and to some students, it is either a second or a third language. Students study both the language of science and English Language at the same time. This created problems. The performance of students were low, however, it was found the performance of students from English medium schools were significantly higher than those from Tswana medium schools.
- Selection to junior secondary school is based on achievement test not on predictive test: Achievement tests allow students with mixed ability range and those of wide ability range including those with low ability to proceed to junior secondary school. Students of low ability find it difficult to pass science in junior secondary schools. A few number of students who proceeded to COSC were also of wide ability range, hence these weak students studied sciences at COSC level but failed the sciences dismally.
- The results of science showed differences in professionalism of teachers on their approach to teaching: This means that some teachers were thorough in their teaching and called for academic rigor and treated science syllabuses in depth to comply with requirements of COSC examiners. However, the number of students who enrolled began to increase and this opened avenues for those students who aspire to study science related careers (Nganunu & Clegg, 1980).

The Three Year Senior Secondary Education Programme

The National Commission on Education of 1977 recommended that the three year junior certificate programme be replaced by the two year junior certificate programme. The recommendation was implemented in 1986 (Republic of Botswana, 1986). This meant that the two year senior secondary school programme was also increased by one year and in 1986, the two year senior secondary school became a three year programme.

The first cohort of the two year junior secondary education entered senior secondary schools in 1988 (Republic of Botswana, 1988). This group of students took three years to complete senior secondary education programme. The science content topics of the three year junior certificate programme were moved to the first year of the three year senior secondary school programme. At the end of the first year of the three year senior secondary school programme, students began to specialize in various science disciplines. Academically strong students took the pure sciences (Biology, Chemistry & Physics) while average students took physics with chemistry and biology while the weaker ones took Combined Science and Human and Social Biology. This grouping of students into three categories was not welcomed by some parents who thought that students doing the pure sciences were the only ones taught properly while the other two groups just scratched the surface of the sciences (Kahn, 1988).

It was expected that the three year senior secondary school programme would help to improve the performance of students in the sciences, but it was not the case (Kahn, 1988). Evidence suggests that the

performance of students in COSC declined (Kahn, 1989). Why was the performance of students in the sciences low yet they took three years instead of two to study senior secondary sciences? The reasons are not farfetched:

- Mismatch of the two years Junior Secondary Science with Cambridge Science Syllabi: Junior secondary school science syllabus concentrated on local science concepts while those of COSC concentrated on abstract concepts which were not meaningful to students and consequently forced students to learn by memorization and this resulted in students not understanding the concepts (Makgothi, 1989). Furthermore there was a shortage of qualified science teachers who could help to teach the sciences.
- Limited Resources: A large number of students who enrolled for COSC increased but the resources remained unchanged. This meant that students missed ‘hands on minds on’ experiences’, hence poor performance in the COSC sciences. There were no specific syllabuses designed for the first year of the three year senior secondary school programme. The departments of science in senior secondary schools taught what they thought students missed in junior secondary schools (Ramathlakola, 2011). Ramathlakola reported that concepts taught included density, measurement, chemical equations., metals and non-metals, cells, living things, etc. Students were given an examination in science at the end of the first year and based on their performance, they were then streamed.

Students who got grade A in junior secondary science were allocated to the pure sciences while those with average performance were placed in combined sciences and in physics with chemistry (formerly called physical science). Those with lower grades (D &E) were allocated to Human and Social Biology.

Although the National Commission on Education of 1977 recommended the establishment of a local examination council to replace Cambridge Overseas School Certificate Examination and to award its own certificates, it was the 1993 National Commission on Education that recommended the implementation of the local examination that would award certificates called Botswana General Certificate of Secondary Education (BGCSE) (Republic of Botswana, 2000, Republic of Botswana, 1977 & 1993). As a result, new science curricula were developed for Botswana Senior Secondary School Education programme.

The current senior secondary school science curricula

Senior secondary education in Botswana is a two year programme and students start to specialize in their first year. Students who obtain grade A & B in the junior certificate examination are placed in the pure sciences (Biology, Chemistry & Physics) while students with grade C and D are normally placed in Science Double Award option while those with grade E are placed in science single award. An option called Human and Social Biology is taken by private students to qualify for the awarded of a BGCSE certificate. Private candidates are not expected to do practical work in science, so Human and Social Biology is the right option for them.

The Botswana General Certificate of Secondary Education science syllabuses came into being in 2000 as was recommended by the National Commission on Education of 1993 (Republic of Botswana, 2000; Republic of Botswana, 1993). Parliament approved the recommendations which are in a policy paper called the Revised National Policy on Education of 1994 (RNPE, 1994). This policy paper guided educators on the development and implementation of new curricula (Republic of Botswana, 1994).

The Revised National Policy on Education of 1994 recommended that science and technology should be taught in schools to enable students to gain skills and knowledge appropriate for the 21st century. Completion of senior secondary school education programme leads to the award of Botswana General Certificate of Secondary Education (BGCSE) by Botswana Examination Council (BEC). BGCSE certificates were awarded to candidates for the first time in 2002 (Botswana Examination Council, 2002).

There are six science subjects offered at the senior secondary school level of education in Botswana, namely (1) Biology (2) Chemistry (3) Physics (4) Science Double Award (5) Science Single Award (6) Human and Social Biology (Republic of Botswana, 2000).

Candidates are awarded a BGCSE certificate if they have studied and passed one science subject. All pure sciences, biology; chemistry and physics have common themes. Science Double and Single Science Awards also have same themes. Human and Social Biology has been organized differently.

Senior Secondary School Biology Syllabus

The biology syllabus has themes that are common to all pure science, namely *Introduction, Rationale, Aims of Senior Secondary Programmes, and Aims of Senior Secondary Science, Recommended Teaching Methods, and Assessment Procedures.*

This syllabus is currently used in Botswana senior secondary schools and forms part of Botswana General Certificate of Secondary Education (BGCSE) Science Subjects. The BGCSE biology syllabus covers the content equivalent to that taught in International General Certificate of Secondary Education (IGCSE). The developers of the BGCSE biology syllabus emphasize the use of process skills.. The BGCSE biology syllabus has two main objectives, namely **Core** and **Extended**—Core objectives are expected to be covered by all students at the end of the programme while extended objectives are expected to be covered by students of high abilities only. Core objectives give the depth of content coverage. Extended objectives give additional content coverage.

Aims of Senior Secondary School Biology Programme

The BGCSE biology syllabus has fifteen aims that every student who takes biology as a course is expected to have mastered at the end of their two year programme. Some aims that are relevant to the 21st century are:

- Develop an understanding of key concepts and principles of biology as they are experienced in everyday life.
- Appreciate the role of biology in improving the quality of life.
- Recognize the usefulness of biology and develop an appreciation of the applicability of biology in other science disciplines.
- Develop an appreciation that biology applications may be both beneficial and detrimental to the individual, the community and the environment.

Recommended Teaching Methods for Biology

The methods include inquiry, demonstration, practical work, case study, field trips, discussion, debate and computer guided learning. These teaching methods will expose learners to practical applications of biology in everyday life activities. The methods intend to make biology more popular, interesting and challenging to students.

Common Sections to all BGCSE Pure Science Subjects

The common sections include:

- **Introduction:** This section provides learners with scientific knowledge, skills and attitudes needed to understand and to participate responsibly in society. The section also provides foundation skills for those who would venture into employment.
- **Rationale:** This section states reasons for teaching the pure sciences and these include: facilitating the holistic development of the learner so that the learner can operate in a global context, teaching

appropriate science concepts to enable learners to cope with a technologically changing world, teaching children skills and competencies that would help them to address environmental issues and to apply science to everyday life.

- **Aims of Senior Secondary Programme:** This section states what is expected of students when they complete senior secondary school programme. Three of the main aims include (i) production of rounded learners capable of creating self employment (ii) production of learners who would survive in a technological world and (iii) production of learners with responsible environmental behaviors.
- **Aims of Senior Secondary School Science Programmes:** Some of the aims of senior secondary school science programme are to: (a) acquire knowledge, attitudes and practices that will promote good family life and health including awareness and management of epidemics such as HIV/AIDS practices that prepare them for productive life (b) develop positive attitudes such as open-mindedness, inventiveness, concern for accuracy and precision, objectivity, integrity, curiosity and initiative towards scientific skills (c) develop an understanding of key concepts and principles of science as they are experienced in everyday life (d) promote an awareness that the application of science may be both beneficial and detrimental to the individual, the community and the environment.
- **(5) Domains:** This section identifies important skills for performing science activities. Domains are essential attributes that students studying the sciences should demonstrate. Domains include: knowledge and understanding of scientific concepts or principles, handling and reporting of scientific information, applying scientific concepts to everyday life activities, solving problems in a scientific way using investigation and experimental skills such as observation, classification, interpretation, questioning, etc., development of scientific attitudes.
- **Recommended Teaching Methods:** Senior secondary science disciplines recommend the use of learner centered methods which encourage ‘hands on minds’ on activities and active participation. The methods include inquiry, demonstration, practical work, case study, which emphasize the use of both process and problem solving skills. The methods are learner-centered, and require plenty of spaces for experiments.
- **Assessment Procedures:** A variety of assessment techniques are used to ensure that learners achieve the stipulated aims. These include projects, tests, experiments, surveys. The use various assessment techniques is to improve instruction and to guide students in their progression, Detailed examination syllabuses were developed by the examining board (Botswana Examination Council (BEC)) to provide teachers with guidelines on the depth of objectives to be tested.
- **Organization of the Syllabus:** The pure science syllabuses are organized around broad content areas subdivided into topics. Each topic consists of general and specific objectives. Specific objectives describe what learners are expected to do. The objectives are divided into core and extended. The core objectives are expected to be covered by all students while the extended objectives provide more challenging work for learners of high ability.

Senior secondary school chemistry syllabus

An analysis of the BGCSE chemistry syllabus suggests that its content is equivalent that of Cambridge IGCSE chemistry syllabus. This is important because the syllabus matches international standards and enables students to study chemistry in other countries. There are five major objectives of BGCSE chemistry. They are given as follows:

- Acquire a systematic body of scientific knowledge and develop an understanding of Chemistry including its strengths and weakness.
- Develop an understanding of key concepts and principles of chemistry as they relate to everyday life experiences.

- Develop abilities and skills that are relevant to the study of chemistry to help students to be productive and adaptive to cope in a changing world.
- Develop positive attitudes towards chemistry.
- Develop desirable attitudes and behavioral patterns in interacting with the environment in a manner that is protective, preserving, developmental and nurturing.

Senior Secondary School Physics Syllabus

This syllabus shares common themes with the other pure sciences. The syllabus is equivalent to the Cambridge IGCSE physics syllabus. The purpose of the syllabus is to ensure that Botswana students are exposed to physics concepts taught internationally. There are ten aims of BGCSE physics syllabus, but only five objectives related to everyday life activities have been chosen and are as follows:

- Develop abilities and skills that are relevant to the study, practice and application of physics which are useful in everyday life, and which encourage safe practice.
- Develop an understanding of the significance of information and technology in the day today life situations and the world of work.
- Encourage students to pursue and suitably prepared for further studies in physics and physics related courses.
- Develop positive attitudes relevant to physics and using inquiry methods in teaching physics.
- Show awareness that physics applications may be both beneficial and detrimental to the individual, the community and the environment.

The Revised National Policy on Education of 1994 has reported that the pure sciences open avenues for students to study science related careers at higher level of education. There are three other science courses also offered at the senior secondary school level of education. These include: Science Double Award, Science Single Award and Human and Social Biology.

Science Double Award

The National Secondary School Science Panel thought that all senior secondary school students should be exposed to science. The panel decided to develop science double award to give students opportunities to learn basic science concepts which they can use in their everyday life activities. Science double award syllabus gives students a thorough grounding in basic concepts in biology, chemistry and physics. Although the concepts taught in science double award are the same as those taught in the pure sciences, the depth of content coverage is below that of the pure sciences. Science Double Award syllabus consists of two thirds of the pure sciences and is equivalent to two subjects, hence the award of two (AA or AB) grades at the BGCSE level. Science Double Award Syllabus is given 320 minutes of teaching time (Republic of Botswana, 2000). It is expected to be completed in a given period of 90hrs of teaching time. Although more content is covered in science double award, a study by the Faculty of Science suggests that higher grades (AA) obtained by students do not tally with their performance in the first year courses of Bachelor of Sciences (Chimidza, et al, 2008). This suggests that science double award syllabus does not provide a strong science background for students to study the sciences at the university level.

Science Single Award

The content of single science award was composed of biology, chemistry and physics. Candidates who sat for the BGCSE examination in this syllabus were awarded a single grade (A or B or C or D). The syllabus was given 160 minutes of teaching per week. It was designed to be completed in 45hrs of teaching time

(Republic of Botswana, 2000). The content of single science award syllabus is not as rigorous as that of science double award. This syllabus was based on the premise that every student who completes senior secondary education programme should have a basic knowledge and understanding of science needed in everyday life. Science Single Award is no longer offered in senior secondary schools because its graduates could not be admitted into science related careers as its content was considered weak.

Human and Social Biology

Human and Social Biology is taught in senior secondary schools to help private candidates to meet the requirements for the award of BGCSE qualification. As stated below:

“The Human and Social Biology programme is designed for private students who have taken General Science or Integrated Science at Junior Secondary Level. It has been designed for students who do not intend to pursue a science related career, therefore do not wish to opt for pure science or science double award, or science single award at senior secondary level. By taking the subject, the private student would be able to fulfill the requirements for Botswana General Certificate of Secondary Education. Human and Social Biology may not be taken with Biology, Chemistry, Physics, Science Double Award or Science Single Award” (Republic of Botswana, 2000, p. 1).

The syllabus contains a rationale which calls for greater understanding and application of scientific concepts and principles relevant for personal and community health. Human and Social Biology has a section on ‘recommended learning methods’ rather than ‘recommended teaching methods’. Process skills are emphasized in Human and Social Biology as they are critical for understanding health issues. Human and Social Biology is organized in modules under which specific process skills are articulated. Changes in science do not just happen, they are influenced by some factors.

Factors that Influenced Curriculum Change

The following factors have influenced changes in the science curriculum in Botswana:

- **National/Research Studies Influence:** Two National/Research studies were conducted to review the entire education system of Botswana. The finding of these studies suggested changes in the science curriculum. The 1977 National Commission on Education (NCE, 1977) recommended that the 1969 primary science be replaced by a user friendly science curriculum which will use locally produced materials. Furthermore, it recommended the use of process objectives. Hence the introduction of the 1982 primary science syllabus in which process skills, and investigatory teaching methods were used. A National Commission on Education of 1993 also recommended the introduction of environmental science in lower primary school classes. The Commission recommended science curricula that emphasize knowledge construction and activity learning. The current science curricula used in both primary and secondary schools were introduced because of National Studies.
- **Economic/Finance Influence:** The economy of Botswana started to flourish in the 1980s due to the sale of diamonds. Money was available to pay for teaching materials and to hold workshops for teachers to familiarize them with new science curricula.
- **Socio-political influence:** New changes in science curricula were introduced because of political stability and social change. Political leaders wanted to have technicians who would drive economic development. Due to social change, concepts such as HIV/AIDS, climate change, etc are now part of our science curricula. Political leaders make sure that the country’s money is not wasted and is used properly to improve the life of citizens.

- **Cultural Influence:** Societal values and traditions have an influence on the development of science curricula in Botswana. Culture determines what content is to be taught, how, it is to be taught. Culture changes with time. Reproductive system was not part of part of primary science in the 1960s but due to HIV/AIDS, it is now accepted as a normal part of the primary curriculum. Science and technology are now part of our culture and as science and technology are used by society..
- **Psychological Influence:** Learning theories proposed by theorists have influenced the development of science curricula. Primary science concepts are taught in a hierarchy from the simplest to the more complex ones. This perception is accorded to Gagne's theory of learning. Primary science topics are also in a spiral form. This supports the view that concepts are learned from simplest to most difficult ones. This perception supports the view that the children's reasoning level increases with age. This view is accorded to both Piaget' and Bruner's theory of intellectual development. Children in science rooms and laboratories work in groups and this encourages discussion. This supports Vygotsky view that 'what children can do together today they can do alone tomorrow'.
- **Teacher competency:** Several changes have been introduced in Botswana science curricula due to the fact that teachers are competent to explain science concepts well since they have received training in science in their pre-service training. Botswana teachers have appropriate qualification in science education and this has facilitated the adoption and implementation of new science curricula. As new changes in science syllabuses are introduced, teachers become uncomfortable with them.

Barriers to Curriculum Change

Newton's third law of motion states that 'to every action there is an equal and opposite reaction'. Likewise, to every change there is an equal and opposite resistance. Changes in the curriculum are not always welcomed by teachers because they feel uncomfortable to teach new things. This creates a psychological conflict in which teachers feel uncomfortable to change from one well known situation to one which is not well known (Dalin, 1973). Howson et al (1981) contended that the known provides security while the unknown is risk taking.

When a new science curriculum is introduced, it meets different reactions. Some teachers support it while others attempt to sabotage it (Dalin, 1973). This situation 'creates conflicts amongst teachers. Howson et al. (1981) also observe 'Different people have different ideologies... arising from a variety of causes, political, religious, educational and social background and will significantly affect the way in which people react to suggested innovation' (p. 6)

When Integrated Science was introduced in 1974, a large number of teachers were against it. They did not value it as a strong science subject. Furthermore, a new biology curriculum which was introduced in 2000, also raised about the availability of staff to teach it. It was asked 'are teachers familiar with concepts such as evolution found in the new curriculum? Is it practical to introduce a new syllabus at this time? Since Botswana follows a centralized system of curriculum development, all schools receive a directive from the Ministry of Education and Skilled Development informing them of the date of implementing a new curriculum. This is a barrier that impedes teacher creativity.

CONCLUSION

This paper traces the reforms that took place during the development of science education in Botswana. Prior to independence in 1966, science education in Botswana emphasized biological and health science concepts in its schools. This was because the livelihood of Batswana solely depended on agriculture. During the post independence period, Botswana began to develop, and consequently required people with different science related careers and emphasis was on mastery of content. Hence 'the content curriculum period'.

In the 1980s, emphasis was on investigation and use of process skills to make learning meaningful. This constituted 'The relevant and meaningful curriculum period.' In the 1990s, Botswana developed science

curricula that addressed social issues. This constituted ‘The Social curriculum period.. At the same time Botswana emphasized the importance of teaching children science to help them construct knowledge and this period could constitute ‘Constructivist period’ .In the 21st century, emphasis was on the development of science and technology. Hence ‘The global technology curriculum period’

The way forward

Based on the developments that took place in Botswana, a National Science panel should be formed composed of primary, junior secondary and senior secondary school teachers. Teachers from the three levels of education could develop quality science curricula and this would reduce the science curriculum mismatch that exists between the levels. To develop quality science curricula, there is a need to establish a National Academy of Science whose task would be to fund and nurture students excelling in the sciences. Members of the National Academy of science should be members in the national science panel. A policy document on National Science Standard must be developed to be used as a benchmark against which curriculum development in science would be based.

REFERENCES

- Bernal, J.D. (1965). *Science in History*. Penguin, England.
- Bruner, J. S. (1961). *Toward a theory of instruction*. Massachusetts: Harvard University Press
- Chimidza, S., Makate, N., Mapitse, R., & Sam, C. (2009). A Report on Entry Qualification to Programmes with Courses in the First Year at the Faculty of Science during the Year 2000-2009. Gaborone: University of Botswana
- Dalin, P. (1973). Case studies of educational innovation, V, OECD, In *Strategies for innovation in education in CERI*, cited in M. Waring, (1979). *The implementation of curriculum change in school science in England and Wales*.
- Harding, J. M., Kelly, P. J., & Nicodemus, R. B. (1976). The study of curriculum change. *Studies in Science Education*, 3, 1-30.
- Hopkin, A.G. (1996). Aid, Education and Cultural Penetration: The Case of Botswana *Compare*, 26(1), 73-90.
- Howson, G., Keitel, C., & Kilpatrick, J. (1981). *Curriculum development in mathematics*. Cambridge: Cambridge University Press.
- Kahn, M. J. (1987). Attitudes towards science and technology issues in policy makers in a developing country., In K. Riquarts (Ed.). *Science & Technology Education and the quality of Life*, Kiel: IPN.
- Kahn, M. J. (1988). In the name of equity curriculum reform in Botswana. *Geneva-Africa*. Vol. XXVIII(2), 63-76.
- Kahn, M. J. (1989). Issues in science education and development in Botswana. *Pula’’: Botswana Journal of African Studies*, 2, 38-47.
- Kahn, M. J. (1990). *Development, dependency and science education: A Botswana case study* Gaborone: National Institute of Development, Research and Documentation, University of Botswana.
- Kgoroba, G. K. (2008). Personal communication. Curriculum development in science education, 13th April, 2008. Mogoditshane in Botswana
- Leburu, F.M, & Rosser, A. (1980). Primary science & teaching, In A. Clegg & M. Kahn (eds.), *Science Education in Botswana*. Botswana Science Teachers Association: Gaborone
- Makgothi, S. (1986). A Comparative study of the new two year and the former three year Integrated Science Syllabuses for junior secondary schools in Botswana. Unpublished Diploma in Advanced Education Studies Dissertation. University of Bristol: Bristol
- Makunga, G. (1980). Junior secondary science teaching. In A. Clegg and M. J. Kahn (Eds.), *Science Education in Botswana* (pp.51-68). Gaborone: Botswana Science Teachers Association.

- Mantswe, A.N. (2005) Personal Communication. The 1969 primary science syllabus. June, 13th. Modipane in Botswana
- Martin, R., Sexton, C., & Gerlovick, J. (2008). Teaching science for all children: Methods of constructing and understanding. (5 ed.). Boston, Massachusetts: Allyn & Bacon.
- Mosothwane, M. (1995). The study of curriculum change in Botswana with special reference to primary science: An historical perspective. *Curriculum Studies*, 3(1), 79-89.
- Mosothwane, M. (2011). The problem of training primary teachers in science: The case of Botswana. *Staff and Educational Development International*, 3(1), 35-52.
- Nganunu, M. (1988) An attempt to write a science curriculum with social relevance for Botswana. *International Journal of Science Education*, 10(4), 441-448.
- Nganunu, M., & Clegg, A. (1980). Senior secondary science teaching. In M. Nganunu & A. Clegg (Eds.), Science Education in Botswana (pp.33-49). Gaborone: Botswana Science Teachers Association.
- Ramatlhakola, B. (2011). Personal Communication on concepts taught in the first year of a three year senior secondary school science. September, 27, 2011
- Rantao, P. M. (1984). Education for commerce and Industry, In, M. J. Crowder (Ed.), Education for development, p.238
- Republic of Botswana (1969). Ministry of Education-Syllabuses-Standard 1 to 7. Ministry of Education, Gaborone: Government Printer
- Republic of Botswana (1973). Manpower and employment in Botswana. Ministry of Finance and Development Planning. Gaborone: Government Printer
- Republic of Botswana (1977C). Education for Kagisano. Report of the National Commission on Education, Volume 1 (Annexes). Gaborone: Government Printer
- Republic of Botswana (1982). Standard 5 to 7 Syllabus. Gaborone, Ministry of Education. Department of Curriculum Development and Evaluation.
- Republic of Botswana (1986). The Two Year Junior Secondary Integrated Science. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (1992). Standard 1- 4 Syllabus. Gaborone: Ministry of Education. Department of Curriculum Development and Evaluation.
- Republic of Botswana (1993). . Primary School syllabus for all primary subjects. Standard 5- 7 Syllabus Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation
- Republic of Botswana (1993). Report of the National Commission on Education. Gaborone: Government Printer
- Republic of Botswana (1993). Report of the National Commission on Education. Gaborone: Government Printer
- Republic of Botswana (1994). The Revised National Policy on Education. Government Policy Paper No.2. Gaborone: Government Printer.
- Republic of Botswana (1996). Three Year Junior secondary Science Syllabus. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation
- Republic of Botswana (2000). Botswana General Certificate of Secondary Education Teaching Syllabus. Biology. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2000). Botswana General Certificate of Secondary Education Teaching Syllabus. Chemistry Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2000). Botswana General Certificate of Secondary Education Teaching Syllabus .Physics. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2000). Botswana General Certificate of Secondary Education Teaching Syllabus. Science Double Award.. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.

- Republic of Botswana (2000). Botswana General Certificate of Secondary Education Teaching Syllabus. Science Single Award. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2000). Botswana General Certificate of Secondary Education Teaching Syllabus. Human and Social Biology. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2001) Curriculum Blue Print: Senior secondary school programme (Revised). Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2002). Lower primary school syllabus: Standard 1-4. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation.
- Republic of Botswana (2005). Upper primary school syllabus: Standard 5-7. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation
- Republic of Botswana (2010). Three Year Junior secondary syllabuses: Science. Gaborone: Ministry of Education, Department of Curriculum Development and Evaluation
- Setidisho, N. O. (1971). Ministry of Education Junior Certificate Syllabus-Science. Gaborone: Government Printer
- Swartland, J. (1988). Interdisciplinary in teaching of science during the first nine to ten years of basic education, In D. Lawton (Ed.), *Innovation in science and technology education*, (pp. 91-99). Paris: UNESCO
- Waring, M. (1979). The implementation of curriculum change in school science in England and Wales. *International Journal of Science Education*, 1(3), 267-275.
- Wolfinger, D. M. (1984). *Teaching science in the elementary school: Content, processes and attitudes*. Boston: Little Brown.

 © IJSRE

ⁱ Dr. Modise Mosothwane, is an Associate Professor of Science Education and biology at the University of Botswana, Gaborone, Botswana. He holds a B.Ed. degree in Math and Biology, M.Ed. in Math Education, Ph.D. in Science Education and Biology. He can be reached via e-mail: MOSOTHWM@mopipi.ub.bw.