

An evaluation of Biological Sciences courses in selected Zimbabwe Universities and their relevance to the 2003-2007 Advanced Level Biology syllabus.

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Abstract

The objective of this study was to evaluate the relevance of courses in the recently introduced Bachelor of Science Education (BScEd) Honours degree and the BSc Honours in Applied Biology programme to the restructured Advanced Level Biology syllabus in Zimbabwe. Trends in the selection of optional topics in A-Level Biology at schools were also examined. National statistics indicated that *Growth, Development and Reproduction* and *Human Health and Disease* were the most frequently selected options in 2001, with selection rates of 93.4% and 81.4%, respectively. In response to questionnaires administered in the Mashonaland Central province, both students and teachers selected *Human Health and Disease* as the most preferred option in the 2003 syllabus. Based on conclusions from an analysis of syllabi, the content of the current A-Level Options, including *Biotechnology*, *Applications of Genetics*, *Human Health and Disease*, and *Applied Plant and Animal Science*, were adequately addressed in the BScEd programme. However, certain deficiencies in the BSc Applied Biology programme were noted in the *Applied Plant and Animal Science* option and the *Ecology* core course. With regard to in-service courses it is therefore recommended that teacher training needs be addressed in newly introduced topics in the A-Level Biology syllabus.

Keywords: Bachelor of Science Education, BSc Applied Biology, Advanced Level Biology syllabus.

Introduction and problem statement

The massive expansion in secondary education in Zimbabwe coincided with the independent resolution of curriculum developers in Science to review the whole approach to Science and Biology teaching in Secondary Schools, as new discoveries in Biological Sciences are constantly being made and are rapidly finding their way into the school curricula. The recognition of the increasing obsolescence of syllabi has resulted in continual restructuring of courses and a departure from the study of concepts and principles to the practical study of the applications of Science and current technology (Ncube, 1997; UNESCO, 1986; Chung, 1989; Hodzi, 1989; Nyagura and Reece, 1990a,b; Ndeya-Ndereya *et al.*, 1997).

The Biology course structure in the Bachelor of Science Education (BScEd) programme was initially adopted from the University of Zimbabwe BSc Biological Sciences programme. Since students in the BScEd course are being trained specifically for the teaching profession, it was the opinion of teaching staff in the BScEd programme that the BSc Biological Sciences course structure did not adequately address training needs for Advanced Level Biology High School

teachers. For these reasons, the BScEd Biological Sciences syllabus was restructured in line with current trends in Biology in an attempt to meet the needs of A-Level Biology educators. Furthermore, the conversion from the former A-Level Biology '9266' Cambridge syllabus to the '9190' Zimbabwe Schools Examinations Council syllabus (Zimbabwe Schools Examination Council, 2003) necessitated a review of the BScEd course structure and teacher-training programme.

This study examines the adequacy of the BScEd course structure and the industrially orientated BSc (Hons) in Applied Biology and Biochemistry course in preparing undergraduate students for A-Level Biology teaching, as a substantial number of graduates from both programmes are absorbed into the education sector for the teaching of A-Level Biology.

The Advanced Level Biology '9190' core syllabus consists of *Cell Structure and Function; Biological Molecules and Water; Enzymes; Cell and Nuclear Division; Genetic Control and Genetic Engineering; Inherited Change and Evolution; Energetics; Transport, regulation and control; Ecology; Growth, Development and Reproduction; Gaseous Exchange in Humans; and Biodiversity*. Candidates will also be assessed in one of the options: *Biotechnology, Applications of Genetics, Human Health and Disease, and Applied Plant and Animal Science*. In the 2001/2002 '9266' syllabus (Zimbabwe Schools Examination Council, 2002), candidates were assessed on two options selected from *Biodiversity, Applied Plant and Animal Science, Applications of Genetics, and Human Health and Disease*.

The objectives of the study were therefore to:

- i. assess the relevance of BScEd (Hons) and BSc (Hons) Applied Biology courses to A-Level Biology Options and core syllabi;
- ii. identify components of the A-level Biology 'Core' and 'Options' syllabi that are not addressed in BScEd (Hons) and BSc (Hons) Applied Biology programmes;
- iii. determine the frequencies, trends and methods of Option selection, both nationally and in the Mashonaland Central region for the purposes of prioritisation in the BSc (Hons) Biology programmes;
- iv. assess the relevance of A-level Biology optional syllabi to the career aspirations of students; and
- v. identify difficulties encountered in the teaching and learning of specific Options.

Findings of the study will be of benefit to:

- i. Biological Sciences Departments at universities, which will be able to tailor their programmes to the needs of the A-Level Biology syllabus, and thus adequately prepare undergraduate students for the teaching of Biology at Advanced Level;
- ii. Zimbabwean Secondary Schools, which will benefit from personnel who are appropriately trained for the teaching of Biology at Advanced Level. Improved teaching practices will be reflected in improvements in student performances in national examinations;
- iii. A-Level Biology teaching staff, who will be more appropriately trained for the teaching of Biology optional syllabi; and

- iv. Students, who will benefit from mentorship by teaching staff who are appropriately trained for the delivery of optional Advanced Level Biology syllabi that match student needs and career aspirations.

Research methodology

Research questions

The study was designed to answer the following research questions:

1. Is the content of the current '9190' A-Level Biology syllabus adequately addressed in the BSc Biology and BScEd course structures offered at Zimbabwe Universities?
2. What was the relative frequency of selection of various optional syllabi by schools and students in the periods 2001-2003?
3. What were the reasons for the selection and avoidance of specific optional syllabi?
4. Does the selection of optional syllabi at A-Level match the career aspirations of students?
5. What were the difficulties encountered in the teaching and learning of specific topics and courses?

Research hypothesis

The course content of the restructured BScEd Biology syllabus at universities in Zimbabwe adequately addresses the course content of the current '9190' A-Level Biology syllabus. However, it is expected that the BSc Applied Biology syllabus may not contain some topics that are core or optional courses in the '9190' A-Level Biology syllabus. BSc Applied Biology graduates employed as A-Level Biology teachers would therefore require in-service training in selected topics.

Course content of BSc and A-level Biology syllabi

Core-courses and Options in the A-Level Biology syllabus were tabulated and matched to BSc Education and BSc Applied Biology course units with a similar content (Tables 1 and 2). Critical topics and courses in the A-Level programme not covered by the BSc programmes were noted. In addition, the course structure and content of the Zimbabwe BScEd Biology programme was evaluated against similar Biology Education programmes offered at Auburn University, South-West Minnesota State University, Washburn University and Buffalo State College (USA).

Collection of national data on selection of Options

National data on the total number of candidates for each optional syllabus in the November 2001 A-Level Biology examinations were obtained from the Zimbabwe Schools Examinations Council. Each candidate in the 2001 examinations was required to answer questions from two optional courses, in addition to questions based on the core-syllabus.

Collection of data on selection of Options in Mashonaland Central

Data on Option selection frequencies and the bases for option selection in the 2001-2002 academic year in the Mashonaland Central province were established through questionnaires.

Student questionnaires were designed to determine the optional syllabi that students were studying, student preferences in optional syllabi, perceived level of difficulty of various options, and career aspirations. The first section of the questionnaire required students to indicate with reasons the two Options that they were studying, two Options that they would have preferred to study, an Option that they least wanted to study, and an Option that they perceived to be the most difficult. The second section required students to indicate their career aspirations and to comment on the relevance of the Options that they were studying to their intended career. Optional syllabi were ranked as 'most preferred', 'least preferred' and 'most difficult', based on the percentage of student responses.

Teacher questionnaires were designed to determine academic and professional backgrounds of A-Level Biology teachers, reasons for Option selection, and difficulties encountered in the teaching of the various Options.

The survey area was confined to Mashonaland Central Province, the location of one of the universities offering a BScEd Biology course. Questionnaires were administered to seventy A-Level Biology students and six A-Level Biology teachers in five of the seven schools offering A-Level Biology in the province. The province has a population of approximately 998 265, representing about 8.5% of the total Zimbabwe population (Zimbabwe Central Statistical Office, 2002).

Data presentation, analysis and interpretation

Coverage of the A- Level Biology syllabus in the BScEd Biological Sciences course structure

An analysis of the A-Level Biology syllabus indicates a closer match with current BScEd courses than with the BSc Applied Biology programme. Complementary A-Level, BScEd and BSc Applied Biology courses are presented in Tables 1 and 2.

Table 1: Coverage of the A-Level Biology (2003-2007) core syllabus in BSc Biological Sciences programmes

A-Level Syllabus courses	Equivalent courses	
	BScEd (Hons)	BSc Applied Biology & Biochemistry(Hons)
Cell structure and function	Molecular and Cell Biology	Cell Biology
Biological Molecules and water	Molecular & Cell Biology Plant Physiology	Chemistry of Biomolecules
Enzymes	Animal Physiology	Enzymology & Immunology
Cell and nuclear division	Molecular and Cell Biology	Cell Biology, Advanced Cell Biology
Genetic control & genetic engineering	Genetics Molecular Biotechnology	Genetics, Molecular Genetics and Biotechnology
Inherited change and evolution	Genetics, Ecology Agricultural Biology Evolutionary Botany	Genetics
Energetics (Photosynthesis, Respiration)	Plant Physiology Animal Physiology	Plant Physiology Animal Physiology Metabolic Processes 1&2
Transport (Xylem, phloem, blood flow)	Plant Physiology Animal Physiology Plant-form and Function Vertebrate Biology	Plant Physiology Animal Physiology
Regulation and control	Animal Physiology Vertebrate Biology	Animal Physiology
Ecology	Ecology Applied Ecology	-
Growth, development and reproduction	Animal/ Plant Physiology Plant form and function Diversity of life I & II Vertebrate Biology Human & Social Biology	Animal Physiology Plant Physiology
Gaseous exchange in humans	Animal Physiology Vertebrate Biology Human and Social Biology	Animal Physiology
Biodiversity (Viruses, bacteria, fungi, algae, plant & animal kingdoms)	Diversity of Life I & II Vertebrate & Invertebrate Biology Evolutionary Botany Plant Form and Function General Microbiology	General microbiology 1 & 2

(Source: Bindura University, 1999, 2001; Zimbabwe Schools Examinations Council, 2002, 2003; National University of Science and Technology, 2007.)

Table 2: Coverage of A-Level Biology (2003-2007) Options in BSc Biological Sciences programmes

2003-2007 Options		
A-Level syllabus Options	Equivalent courses	
	BScEd	BSc Applied Biology & Biochemistry
Biotechnology (Food Biotechnology, Medical Biotechnology, Agricultural Biotechnology, Sewage Disposal & Composting)	Molecular Biotechnology Applied Bacteriology and Mycology Agricultural Biology	Enzyme Biotechnology Molecular genetics and Biotechnology Advanced Applied Microbiology Advanced Biotechnology of pharmaceutical products Principles of Fermentation Technology Food Technology 1&2
Applications of Genetics (Selective breeding, Diversity, Genetic engineering, Human genetics)	Genetics Genetic diversity Molecular Biotechnology Agricultural Biology	Genetics Molecular genetics and Biotechnology
Human Health & Disease (Diet, Gaseous exchange, Exercise, Drugs, Immunity, Infectious diseases)	Human and Social Biology Virology and Immunology Animal Physiology	Animal Physiology General Microbiology Enzymology & Immunology
Applied Plant and Animal Science (C3, C4 metabolism. Soil fertility, Crop and livestock production, Food distribution)	Plant Physiology Agricultural Biology	Plant Physiology

(Source: Bindura University, 1999, 2001; Zimbabwe Schools Examinations Council, 2002, 2003; National University of Science and Technology, 2007.)

A-Level core courses are adequately represented in the BScEd course structure, with *Biological molecules* now incorporated in the *Cell and Molecular Biology* course. The Options *Applied Plant and Animal Science* and *Human Health and Disease* are also complemented by *Agricultural Biology* and *Human and Social Biology* courses, respectively. *Biotechnology* is catered for by the BScEd courses *Applied Bacteriology and Mycology*, *Molecular Biotechnology* and *Agricultural Biology*. The BSc Applied Biology programme, however, does not adequately cover *Ecology*, *Biodiversity*, *Evolution* and *Applied Plant and Animal Science*.

Option selection frequencies

National data about the number of candidates sitting for each of the Biology Options in the November 2001 examination indicated *Growth, Development and Reproduction* to be the most popular, with a selection frequency of 93.4%, closely followed by *Human Health and Disease*, with a selection frequency of 81.4%. The least popular Options were *Applications of Genetics*

and *Applied Plant and Animal Science*, with selection frequencies of 3.6% and 6.8%, respectively (Table 3).

Table 3: National A-Level Biology Option selection frequencies in 2002 November Examinations

Option	No. of candidates	Ranking
Growth, Development and Reproduction	1885 (93.4%)	1
Human Health and Disease	1644 (81.4%)	2
Biodiversity	297 (14.8%)	3
Applied Plant and Animal Science	138 (6.8%)	4
Application of Genetics	72 (3.6%)	5

(Source: Zimbabwe Schools Examinations Council (personal communication, 2002).)

National Option selection trends in the 2001 examinations were similar to those observed in Mashonaland Central Schools in the 2001-2002 academic years, with all five schools in the study selecting *Growth, Development and Reproduction* and *Human Health and Disease* in the 2002 November examinations (Table 4). *Biodiversity*, the third most popular Option was selected by only one of the five Mashonaland Central Schools in the 2001 academic year.

Table 4: A-Level Biology Option selection frequencies (2001-2002) in five Mashonaland Central Schools

Option	% Selection frequency (by schools)	
	2001	2002
Growth, Development and Reproduction	100	100
Human Health & Disease	80	100
Biodiversity	20	0
Applied Plant and Animal Science	0	0
Applications of Genetics	0	0

Difficulties associated with particular Options cited by teachers and BScEd graduates before the restructuring of BScEd courses were terminology in *Biodiversity*, access to current statistics in *Human Health and Disease*, lack of resource materials and text-books in *Applications of Genetics*, and the novelty of *Biotechnology* (Mkandawire and Marira,1993; Johnston,1997; Zesaguli,1994). Option selection patterns in 2001 showed an increase in popularity of *Human Health and Disease* from fourth preference in a 1994 survey (Dube,1994) to the second most selected Option. The popularity of the *Human Health and Disease* option is consistent with career aspirations of students, with 85% of participants in the survey indicating the medical field as their first preference (Table 5).

Table 5: Option and career preferences of 2002 Upper Sixth Form Biology students in Mashonaland Central Province

Ranking in Student preference	Option	Career
1	Growth, Development & Reproduction	Medicine (60%)
2	Human Health and Disease	Physiotherapy (12%)
3	Applied Plant and Animal Science	Biotechnology (9%)
4	Applications of Genetics	Dentistry (7%)
5	Biodiversity	Biology (6%)
6		Pharmacy (3%)
7		Radiography (3%)

For the four 2003 Options, the order of preference by teachers was *Human Health and Disease*, *Applied Plant and Animal Science*, *Biotechnology* and *Applications of Genetics*, while 75% of students selected *Human Health and Disease* and 17% selected *Biotechnology* as their first preference. In a 1992-1996 study on Option selection patterns in twenty schools in Gweru, Harare, Marondera and Norton, it was shown that *Growth, Development and Reproduction*; *Biodiversity*; and *Applied Plant and Animal Science* were the most frequently selected Options with 77, 55 and 45 selections by interviewed students, respectively. *Human Health and Disease* and *Applications of Genetics* were the least popular options, with 16 and 8 selections, respectively. Similarly, a survey of ten schools in Bulawayo showed *Growth, Development and Reproduction* and *Biodiversity* to be the most frequently studied Options, while *Human Health and Disease* and *Applications of Genetics* were the least frequently selected (Dube, 1994). In the same study, student preferences were, however, ranked in the order of *Human Health and Disease*; *Growth, Development and Reproduction*; *Applications of Genetics*; *Biodiversity*, and *Applied Plant and Animal Science*, with 87, 44, 41, 28 and 26 selections respectively.

The reasons proffered for Option selection by teachers were resource availability, relationship with core syllabus, perceived length of the Option, student interest, student career aspirations, and degree of concept difficulty. Student preferences were based on level of Option difficulty, general interest, relevance to everyday life and social issues, relevance of the Option to tertiary training and career aspirations, availability of textbooks and resources, and links with other subjects and the core syllabus. Preferred career choices were listed as Medicine, Agriculture, Physiotherapy, Veterinary Science, Biochemistry, Pharmacology, Biology, Dentistry and Dietetics.

Teacher training needs for implementation of Biology Options syllabi

In a survey on teachers' perceptions of the major contributing factors to students' success, 48.8% listed effective teaching as the single most important factor (Johnston, 1997). It has been argued by Mkandawire and Marira (1993) that improving the quality of teaching skills has greater impact on student learning than improving the physical infrastructure. Teacher competency should therefore be taken into account before the implementation of new syllabi. In a related study (Hodzi, 1989), a large percentage of teachers indicated that they needed more content

information on topics such as Animal Management and Health (66%), Human Health and Disease, Virology and Natural and artificial Ecosystems.

The difficulties faced by teachers in implementing the changing A-Level Biology syllabus are well summarised in the following response by a Bachelor of Education (BEd) graduate:

'I feel that the BEd program prepared me adequately both theoretically and practically for my A-Level teaching, although because of the current changes or restructuring in the syllabus I am finding problems here and there. When I did my BEd program I was adequately prepared for the syllabus which was in schools at that time. But the syllabus has since changed. With the core syllabus I am okay. It is with certain option topics which have been included where I find some problems e.g. 'Issues in Contemporary Society and Applications of Science. (Zesaguli, 1994.)

Comparison of local and international BScEd Biology curricula

Core courses in the BScEd Biology courses offered at Auburn University, South-West Minnesota State University, Washburn University and Buffalo State College in the USA are listed in Table 6. All the Biology modules in the four University programmes are covered adequately in the Zimbabwe BScEd course, with no deficiencies in the course structure being evident.

Table 6: Course modules in BScEd Biology programmes at Auburn University, South-West Minnesota State University, Washburn University and Buffalo State College.

Auburn University	South-West Minnesota	Washburn	Buffalo State
Principles of Biology Organismal Biology Human Anatomy and Physiology Genetics Evolution and Systematics Principles of Ecology Plant Biology Invertebrate biodiversity Vertebrate biodiversity Animal Physiology	Cell Biology Zoology Anatomy & Physiology Botany Genetics Microbiology Ecology	Cell Biology Zoology Animal Physiology Botany/ Systematic Botany Genetics Microbiology Ecology Human Physiology Human Anatomy Evolutionary Biology Electives Entomology Human Genetics Parasitology Histology Vertebrate Embryology Vertebrate Anatomy Immunology Microbial Human diseases Virology Plant Anatomy & Physiology	Cell Biology & Genetics Organismal Biology & diversity Ecology, Evolution and Behavior. Human Anatomy & Physiology Comparative-Animal Physiology Biostatistics

(Source: Auburn University, 2007; Buffalo State College, 2007; South-West Minnesota State University, 2007; Washburn University, 2007.)

Conclusions

The following conclusions were made based on the analysis of course structures and Option selection frequencies:

1. The A-Level Biology optional syllabi are adequately addressed in the current BScEd programme through newly introduced courses such as *Human & Social Biology*, *Agricultural Biology*, *Molecular Biotechnology*, *Applied Bacteriology & Mycology*, and *Virology & Immunology*. Graduates from the BScEd programme are therefore adequately equipped to teach the A-Level Core and Optional syllabi. However, the core Ecology course in the A-Level syllabus is not addressed in the BSc Applied Biology programme.
2. A-Level Biology teachers graduating from BSc programmes that do not adequately cover core and optional courses in the A-Level syllabus should be encouraged to participate in in-service training courses. Workshops in *General Plant and Animal Ecology* are suggested for BSc Applied Biology and Biochemistry graduates, while the rapid advances in recombinant DNA technology have been cited by many teachers as an area that requires particular attention in training workshops.

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