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BOTANICAL GARDENS HERBARIA AND MUSEUMS AS RE-SOURCES FOR TEACHING HIGH SCHOOL BIOLOGY

E. M. Gwimbi
Department of Science & Mathematics Education
University of Zimbabwe

Abstract

The 'A' Level biology syllabus used in Zimbabwe has been reviewed at least twice since 1990. It now consists of Core and Option sections. Biodiversity as a concept now constitutes one of the five options. Analysis of option choices at different centres shows biodiversity to be one of the most popular. Despite this, reports from examiners and comments by pupils show that some problems are being experienced in the teaching and learning of biodiversity. This article suggests some ideas on how biology teachers doing this option may enhance the learning of it at 'A' Level.

Background

Current changes in high school biology syllabi used in Zimbabwe show a move towards the process oriented approach. There is increasing emphasis on the applications of biology and the impact of recent developments in it on the needs of contemporary society. Since 1990, the A'Level biology syllabus was reviewed twice. The current version consists of Core, and Option sections. Both are covered in 260 hours. It is expected that practical activities underpin the teaching of the syllabus and to that end, 13,5% of the teaching time is devoted to practical work.

The core syllabus consists of ten topics, to be covered in about 135 hours (51,9%) of the teaching time. There are five option areas: Biodiversity; Applied Plant and Animal Science; Applications of Genetics; Growth and Development; and Health and Disease. From these, candidates should select two to study for examinations. Each lasts 45 hours (17,3%) of the syllabus time. Significant in these options is the emphasis placed on social and applied aspects of biology in all topics. Assessment expects candidates to exhibit understanding of the social, ethical, economic, environmental implications and applications of the biology they are studying.

Of the five options, Biodiversity is one most frequently chosen by candidates (Dube, 1994). However, there are indications that, despite its popularity, teachers/students are meeting with problems in terms of fulfilling syllabus objectives. Such problems relate to the teaching approach adopted (Moyo, 1994; UCLES Exam Reports, 1992; 1991; 1987). This paper tries to share with teachers, ideas on how the teaching of Biodiversity in school biology could be enhanced through use of community resources like Botanical Gardens, Herbaria and Museums.

The Concept of Biodiversity

Biodiversity refers to "the total variety of all life forms on earth (animals, microbes and plants), and life processes including all ecological interactions and life supporting processes in the biosphere" (Cotterill, Hustler, Sparrow & Broadley, 1993:32). This variety of known living organisms is classified into five broad groups: Monera; Protoctista; Fungi; Animals and Plants.

In the A'Level biology syllabus, the study of biodiversity is done under four themes: Microorganisms, Plant and Animal Diversity, Animal Adaptations and Maintenance of Biodiversity. The definition for biodiversity in the preceding paragraph suggests that the concept is simple for pupils to follow. However, as indicated in the cited researches and examination reports, it should be appreciated that plant and animal identification, especially in the natural environment are complex processes. To reduce the difficulties for the learners, proper conceptual development in these areas demands that the teaching/learning be conducted in the natural environment as much as possible. It should be expected that experts on biodiversity like zoologists and botanists working in nature reserves are invited to assist students in developing the requisite skills and knowledge of taxonomy. This should be so because the teaching of the unit is expected to achieve among others, the following objectives:

- Appreciation of the wide diversity based on first hand observation.
- Respect for all organisms and their environments.
- Understanding of how some animals are adapted to their environment.
- Understanding of the need to maintain biodiversity through conservation (UNCLES 9266, 1996:60)

For teaching purposes the best sources of ideas and examples of biodiversity apart from the natural environment near the school are botanical gardens, herbaria and museums. At these centres, there are highly qualified botanists and zoologists whose knowl-

edge and research findings could be exploited through integration into 'A' Level biology studies. Students can be assisted by these experts to carry out specific study tasks that would enhance their knowledge and skills on biodiversity. Such integration has the added advantage of making the learners experience the social and applied dimension of their school studies. They are also exposed to potential career opportunities as they interact with specialists in applied biology.

Current Situation in the Teaching of Biodiversity

Biodiversity as an option is one of the most commonly chosen by A'Level biology candidates in Zimbabwe (Dube, 1994). One reason for this is the perceived general ease with which materials can be sourced. However, there are indications that practical experiences are not being used in teaching as much as is expected. Moyo (1994), in a survey of 10 Bulawayo schools studying the option at A'Level, found that 60% of the students expressed difficulty in identifying organisms studied in class when seen in their natural environment. It was found that the Natural History Museum of Zimbabwe (in Bulawayo) which could cater for Biodiversity education up to university level was used by very few schools. ". . . unfortunately, the crucial function of these institutions is all too often unknown or ignored" (Moyo, 1994:7). Analysis of the University of Cambridge Exam Reports in Biological Sciences also highlights the general lack of exposure of students to adequate practicals during study of biodiversity. Examples of such reports are those of 1987, 1991 and 1992.

Although the offering of biodiversity as an option started in 1991, the concept itself has always been an element of the A'Level Biology syllabus. In 1987 for example, question 7 of paper 1 was based on biodiversity. Highlighting lack of practical experience on the part of the students, examiners reported that: question 7 "was the most unpopular question . . . the first part proved too difficult for most candidates . . . accounts of annelid and arthropod locomotion were often poor."

Related problems are highlighted in the 1991 and 1992 reports. In 1991, candidates could not correctly describe functions of flagella in unicellular organisms. They could not suggest practical problems likely to be faced by a biologist studying unicellular algae. Issues like problems of size, distinguishing various phases of development in some species and observing fertilization were hardly suggested. In another question, students failed to bring out observable features of comparison in gaseous exchange systems in mammals and insects. In 1992, candidates could not correctly identify

structural features of a saprophytic fungus. What therefore seems to be the problem is the approach used in schools in teaching the option of biodiversity. "Some centres appear to be leaving the study of the option entirely to the candidates themselves" (UCLES, 1991:39). If this is the case, it is highly unlikely that candidates could effectively organise the necessary practicals to meet syllabus expectations. The 1991 syllabus highlights that candidates should:

>appreciate the wide diversity of organisms based on first hand observation . . . field work . . . carried out to study living examples of organisms listed in their natural habitats to demonstrate . . . environmental adaptations.
>
>(UCLES 1991:61)

The current syllabus, apart from the objectives highlighted under biodiversity, also specifically states that "practical activities will underpin the teaching of the whole syllabus." (UCLES 9266, 1996:55). Conceptual problems encountered by pupils as they study biodiversity need to be addressed. Community resources with facilities allowing practical experience of biodiversity should be harnessed.

Botanical Gardens, Herbaria and Museums as Sources of Biodiversity Experience

Increasing urbanisation and general change in natural ecosystems has deprived many biology classes of contact with natural sources of biodiversity like velds, forests and unpolluted rivers, where fieldwork and case studies could be done to fulfil requirements of some science programes like the A'Level biology option of biodiverstiy. Compounding the problem is the concentration of high schools needing such environments in urban areas. Harare alone for example has 32 (25,6%) of the 125 A'Level schools in Zimbabwe (Engels, 1996).

Since, as Tobin et al (1993) suggest:

>Teaching is essentially helping people get excited in a subject area . . .
>(it) should appreciate the role of the social in mediation of learning . . .
>maximise social interaction between learners and . . . provide a variety of . .
>. experiences from which learning is built, (Tobin, Tippins & Gallard, 1993:45)

there is need, to consider the potency, of community resources like botanical gardens, herbaria and museums situated in and around urban centres in maximising learners' experience of biodiversity. Alternative sources of biodiversity experience could be

National Parks and Game Reserves, Farms and Rivers. Case studies/field exercises carried in such places provide pupils with the following opportunities and practical means of effectively studying biodiversity.

·   gathering and manipulating data.
·   developing skills in logical thinking and organisation regarding for ex
          ample, science and society issues.
·   building values concerning the nature of science i.e. knowing/under
          standing, questioning, search for data, demand for verification and
          consideration of consequences, etc.
·   being exposed to some applied aspects of biology like taxonomy and
          use of microorganisms   in biotechnology.

We briefly consider the potency of botanical gardens, herbaria and museums as sources of biodiversity experience.

i)   **Botanical Gardens and Herbaria**

These are establishments within the Department   of Research and
Specialist Services under the Ministry of Agriculture. There are 22 such
establishments in Zimbabwe (Nobanda, 1994). The best examples are the National
Botanic Garden and National Herbarium in Harare. The two are closely
related and interdependent. The garden serves as a collection of live plants while the herbarium is a collection of dead plant samples collected from within Zimbabwe. Both are important in advancement of plant science especially taxonomy, ecology and ethnobotany. They also serve as sites of   exsitu conservation of geneic resources (seeds and plants). This provides a National Genebank where germ plasma are col-lected, evaluated, and documented (Mhlanga, 1992).

The National Botanic Garden is formerly a Miombo woodland transformed into a miniture Zimbabwe in terms of woody vegetation. Over 2080 or 87,8% of Zimbabwe's woody species are found here (Nobanda, 1994). They are representative of species from the highveld, lowveld, rainforest and riverine areas. Among them are important taxa like Ficus; Acacia; Combretaceae, plants of economic value like tea, rubber, jojoba and some exotics from countries with similar climate.   Students of biology need to be exposed to this rich diversity.

The National Herbarium on the other hand holds a collection of nearly 500 000 plant

specimens from Zimbabwe (Nobanda, 1984). These are complete with information on recognition, classification, distribution, ecology and uses. This unit also provides a free public service like identification of specimens brought by students, farmers, traditional healers and researchers. Pupils need to be exposed to such an important resource.

ii)   The Natural History Museums of Zimbabwe

Most urban centres in Zimbabwe have their own museums. The largest one in Zimbabwe is found in Bulawayo. It holds one of the largest collections of Afrotropical fauna in the southern hemisphere and is thus a key participant in conservation of biodiversity. Its major activities include collating, analysis, archiving and dissemination of information on biodiversity of fauna (Cotterill et al, 1993). For teaching purposes, it caters for the needs of diverse levels of learners - schools, colleges, universities and conservation agencies. Tabulated below are some estimates on some of its collections.

Table 1: Collections In the Natural History Museum of Zimbabwe

Department	Specimens	Type Specimens	Species
Entomology (Insects)	5 000 000	3 000	50 000+
Herpetology (snakes, lizards)	60 000	60	600+
Ichthyology (fish)	50 000	40	300+
Invertebrates (worms, etc)	30 000	20+	5 000+
Mammalogy(mammals)	100 000	5	300+
Ornithology (birds) (Over 12 000 egg clutches)	95 000	40	2 000+

Palaeotology: Important Triassic dinosaur material, including valuable types of early Archosauria

(Cotteria, Hustler, Sparrow & Broadley, (27) 1993:33)

Teachers of biology need to exploit the richness of such a resource in teaching the concept of biodiversity. Organised field trips to such resources as above could be used by teachers to fulfil some of these outcomes regarding the learning of pupils.

- appreciating the diversity of plants and animals.
- tracing the natural history (evolutionary trends in groups of organ isms).
- identifying and classifying some familiar organisms.
- discover adaptations that organisms make to their habitats.
- appreciate the need to conserve and preserve nature for posterity.
- see and appreciate evidence and role of the resource as a research centre.
- consult the library facility at the centre for literature specific to plant and animal diversity.

For the above centres to sufficiently fulfil their roles as community resources in education, it would be worthwhile for those responsible for running the institutions to liaison with those in schools and colleges. There is need to draw programmes that address the specific interests of the groups visiting them. Teachers for example, need to suggest to them, the specific aspects of their syllabi relating to aspects like collection, identification and storage of specimens, ecology, conservation and research which typify activities at the centres. There is also need to train the specialists at these resources for the added responsibility of being facilitators of learning when school visits to their centres are organised. On the other hand, it needs to be appreciated that the effectiveness of these resource centres in fulfilling this role adequately would depend on a number of factors. There is need for advance notice concerning intended visits. Their help would also depend on the size of the visiting groups, the resources at their disposal including time, as well as the clarity of the visitors' objectives. Teachers also need to be aware of regulations governing their accessibility to such centres so as to plan well in advance on issues like permission, admission fees and other needs.

Examples of Biodiversity Concepts/Skills to be Done at the Centres

Learning activities should extend beyond the classrooms and laboratories to maximise concept, skills and attitude development on biodiversity. This can be done through organised field trips and or case studies to resource centres concerned with diversity. Examples of concepts warranting field visits include the following:

i)   Plant and Animal diversity

diagnostic features exhibited by different plant/animal taxa (use of both live and preserved specimens).

- adaptive features apparent in the different animal taxa regarding feeding, locomotion and gaseous exchange.
- biotechnology and diversity eg inoculant culture of bacteria associated with leguminous plants at Grasslands Research Station in Marondera.

ii)   Levels of ecological organisation; habitats, niches, populations, food chains/webs/cycles, community, ecosystems, sampling techniques.

iii)   Conservation
- ecological importance of particular ecosystems like rain forests.
- economic and ethical reasons for maintaining biodiversity as examplified by the National Genebank of Zimbabwe
- conflicts of interest in conservation of particular organisms eg the elephant.

Planning for Teaching Biodiversity Through Field Visits

Before the actual visit, teachers need to think of the position of the topic in the general scheme. They should select relevant content and identify objectives for the visit. They should acquaint themselves with the resource through maps, records, reports and an initial visit to the place to discuss with authorities, the nature and purpose of visit. The time required, material needs and special clothes, food, and others need to be thought of. Necessary handouts and worksheets to be used by the pupils need to be ready. There is also need to formalise travel arrangements. This will entail seeking permission from the school head, who inturn facilitates time table adjustments, communication with parents and getting permission from education authorities. Transport needs to be booked and paid for in advance ensuring that it has an insurance cover in case of an accident.

On the day of the visit, it may be necessary for the teacher to seek help from a colleague if the group is large. Pupils should be given the necessary requirements and organised into smaller groups for purposes of the tour activities.

The actual visit may be organised into two activities. The first could be a general tour of the resource centre. This could involve an overview lecture by the authority at the

resource centre, an outline of the sites to be gone through and the actual visitation of the sites where students are exposed to underlying biological principles. After the general tour, the class may be split into prearranged groups for purposes of carrying out specific tasks with assistance from the resource centre staff. The group tasks could include activities like: identification and classification of previously collected specimens; determination and discussion of bioethical issues of relevance to the centre like preservation of nature reserves versus resource development, formation of gene banks; adaptations exhibited by particular taxa; or do particular ecological exercises requiring use of particular techniques.

The few days following the visit should be used to consolidate gains made through the visit - particularly the group activities. Group findings should be shared with the whole class through oral and written reports. Such reports would enable the class to practice some of the skills the syllabus expects them to master. Important in assessing such reports would be factors like: clarity in identification of task purposes; selection of suitable presentation formats for both numerical and non-numerical biological information, analysis of data, use of relevant biological principles to construct explanations and conclusions and finally communicating the information coherently orally and in written form to others.

In order to make the field visits successful, teachers need to be aware of potential factors that may militate against the visit. These may relate to the type to the school and its relative distance from the resource centre. Teachers need to be aware that organisational requirements like arrangements with authorities, initial visits, making of worksheets, arranging transport need careful thought and time. Leaving these till late will create a very diso janised trip. The financial requirements need to be clearly thought out and contributions by school and parents or pupils clarified well in time. In appreciation of the problems that can be faced in raising enough trip funds for the above purpose, school authorities could explore possibilities of levying those doing Biology at 'A' Level, forming links with local industries to which pupils are attached during vacations and/or forming 'A' Level biology production clubs for raising chicken, rabbits, vegetables and even pigs for sale. This ensures that everyone contributes to trip funds thus ensuring equal opportunity for all pupils to effective teaching and learning. Besides sourcing funds, the value of such trips needs to be canvased for among other subject teachers whose time-tables may be disrupted. They are supposed to be morally supportive. Safety and security of the students need to be carefully thought about.

Conclusion

This article has indicated that biodiversity is one of the most commonly chosen options in biology at 'A' Level. However, because present day schools are very much removed from natural ecosystems, students have no ready access to biological diversity as specified by syllabus requirements. Pupil performance in questions covering diversity issues shows that teaching in most cases is not practical in orientation. The existence of centres where biodiversity concepts may be practically encountered requires that teachers exploit them to assist the educational process. This not only broadens students' horizons of knowledge but that of the teachers as well. Some needs which teachers should be aware of have been highlighted.

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