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IT and Environmental Education: An Exemplar Project

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This paper reviews the use of information technology to support teaching and learning in environmental education. Issues in this area are illustrated in terms of the work of a current TEMPUS project which is concerned with the development and revision of university-level environmental studies curricula at the Technical University-Sofia and the establishment of a national river pollution data exchange network. This curriculum development involves a revision of both process and content.

INTRODUCTION

THERE is now widespread concern about the relationship between humankind and the environment. How can the Earth's resources be conserved? Can pollution be controlled and minimised? What strategies are appropriate in order to sustain development? Are there limits to economic growth? These and similar questions have promoted environmental education as an essential component of the curriculum at all levels. The relevance of this emphasis on environmental education to the economic restructuring of central and eastern Europe (CEE) is illustrated through the choice of priority areas for the current European Community (EC) scheme for cooperation and mobility in higher education between CEE and the EC. The Trans-European Mobility Scheme for University Studies (TEMPUS) has 'environmental protection' as a priority area for four of the original six eligible CEE countries and 'ecology and natural conservation' as a priority for one of the two other eligible countries [1]. Given the current widespread desire to introduce and expand environmental education it is imperative that appropriate curricula and effective pedagogies are identified and established in the education infrastructure.

The use of information technology (IT) to support teaching and learning is now established at all levels, with claims that IT can improve existing educational practice and introduce exciting new approaches to teaching and learning. Given the needs to develop new environmental education curricula and related teaching practice there is a strong case for investigating the potential of IT to support, enhance and develop work in environmental education. Computer-based Environmental Studies (COBES), a current TEMPUS project based on cooperation between the Institute for Science Education (Germany), King's College London (UK), and the Technical University-Sofia (Bulgaria), is designed to explore these issues through the formal development of university-level environmental studies curricula which make extensive use of IT, and the informal promotion of public awareness of environmental issues through the establishment of a national river pollution data exchange network [2].

INFORMATION TECHNOLOGY AND ENVIRONMENTAL EDUCATION

Environmental studies is concerned with study in a number of established areas of the curriculum: ecological and biological studies provide an essential scientific basis; law and engineering provide practical and problem-solving techniques; music, art and literature provide an aesthetic basis for the consideration of environmental issues [3]. However, environmental studies consists of more than an eclectic collection of facts, ideas, and concepts 'borrowed' from a selection of separate subject areas; in its proper manifestation it provides a comprehensive and coherent framework for thinking about environmental issues. Thus, whilst it is possible to identify a variety of uses of IT which may support the development of knowledge and understanding in specific areas of the curriculum which have environmental relevance, the role of IT in the development of coherent environmental thinking and problem-solving techniques must also be considered. The development of a coherent holistic view of environmental issues is often best

achieved by adopting an interdisciplinary approach. Within this context there are a wide variety of IT applications which could support teaching and learning in environmental education. In a review of the use of IT in environmental education, Page identifies two particularly significant areas in which IT relates to environmental education: (i) modelling and simulation, emphasising work in economics and ecology; and (ii) data collection and analysis, citing the collection of water and air pollution data as examples [4].

The use of simulations and modelling systems

Environmental changes are typically long term and topographically extensive (even global), making it difficult to study such changes in the restricted context of a classroom or teaching laboratory. Computer-based simulations may be of great value here as systems and processes which change over long time-scales or which are extensively located can be simulated, providing students with opportunities to explore the relative significance of relevant parameters in a way which would not be possible in conventional teaching situations. A classic example of a simulation which deals with issues of this type is *Pond Ecology* [5], in which it is possible to change the number of anglers, the frequency of fishing, and the level of pollution to investigate changes in the levels of fish and micro-organisms in the pond. Computer-based simulations can also provide role-playing environments in which students are required to make decisions which have environmental, economic and social consequences. In this way the simulations provide a medium in which students can exercise practical problem-solving skills. *Siting an Aluminium Plant* [6] is an example of a simulation which aims to provide an experiential environment in which students can develop decision-making and problem-solving skills. This is illustrated by the stated aims of the simulation which include the following:

- To understand the economics of the process [extraction of aluminium]; the relative importance of each step and the importance of investment, capacity and power supply on costs.
- To make the subject decisions about the siting of the plant on environmental as well as economic grounds.

The use of modelling systems opens up the possibility of students expressing their own ideas concerned with environmental issues through the proposition and development of computer-based models. These models can then be explored in order to assess their usefulness and validity. This contrasts with the use of simulations which are based on given models of systems and processes. As such, simulations present students with exploratory environments that are expressed in terms of other people's ideas and perceptions of environmental issues. Modelling systems designed with education in mind are now becoming more widely available. A well-known example is *Stella* [7], which allows models to be defined pictorially in terms of a metaphorical representation based on the notion of flow. Other modelling systems with educational aims include the *Dynamic Modelling System* [8] (for which a set of exemplar biology models exists), *Model Builder* [9], and *Expert Builder* [10].

Data collection and analysis

A proper critical examination of environmental issues needs to make reference to environmental data in order to identify patterns in environmental change. Data that are typically available to students come from national and international databases. However, in order to demonstrate relevance and to compare local change with more global change it is important for students to have access to quality local data. Unfortunately the collection of data is a time-consuming and often difficult task, as environmental data typically needs to be collected over long time-periods, at frequent intervals, and in a variety of locations. Data-logging, in which remote sensors connected to a computer automatically log data, can help to overcome some of these difficulties. This technique enables students reliably to collect significant amounts of data over extended time-periods at frequent intervals in a variety of locations, opening up possibilities for the collection of local databases. These local databases can be exchanged between groups leading to the creation of a national database.

The collection of relevant data is obviously of critical importance, but the data is of no great educational significance unless it can be analysed in an attempt to explore environmental trends. Such an analysis is usually a non-trivial exercise, with the need to be able to represent the data in various numerical and graphical forms corresponding to criteria associated with proposed hypotheses. Information-handling software enables data to be rapidly and efficiently interrogated according to the specification of criteria relating to hypotheses under consideration. It is also possible to represent the results of these interrogations in a variety of numerical and graphical forms. Hence information-handling software can be seen as providing a very important contribution to the analysis and interrogation of data by students.

THE COMPUTER-BASED ENVIRONMENTAL STUDIES PROJECT

The fundamental aims of the COBES project are to integrate the revision and development of university-level environmental studies curricula with the extensive use of IT (particularly the data-logging of water quality), and to use IT to support the establishment of a national river pollution database designed to publicly highlight environmental issues. Existing courses within the Technical University-Sofia are providing a context for this work. Courses in ecology, chemistry and computer

Table 1. Pilot scheme for Task 1

Date	Curriculum area	Level
March 1992	Chemistry (water pollution laboratory)	undergraduate
March & April 1992	Ecology	postgraduate
May &June 1992	Environmental control (water control in engineering ecology)	undergraduate
1991/2	Regional ecology (water pollution)*	public
January 1993	Chemistry (water pollution)	undergraduate
March 1993	Databases and computer graphics	undergraduate
May & June 1994	Environmental engineering	undergraduate

* Organised by the Open University - Union for the Protection of Nature

science have been chosen from across the curriculum (see Table 1), emphasising an interdisciplinary approach. Students following chemistry courses are sampling data, and computer science students are adapting relevant software packages. Curriculum developments are supported by the extensive use of IT to support teaching and learning, with courses being revised both in terms of process and content. IT support is currently focused on the collection and analysis of data to provide illustrative curriculum materials. Data-logging equipment is being used to collect data concerned with the levels of pollution in Bulgarian rivers, and information-handling software is being used to analyse this data. It is planned to incorporate the use of modelling and simulation software as the project progresses. Three related tasks emerge from this project framework.

- Task 1 consists of two related sub-tasks: (a) to develop or to improve environmental studies curricula and (b) to identify appropriate and relevant uses of IT in these curricula.
- Task 2 is to identify and integrate the use of computer-based learning in the delivery of the curricula developed in Task 1. It is planned to adapt pieces of educational software as an integral part of the project. This idea would be based on the adaptation of existing EC educational software to produce Bulgarian language versions. Information-handling tools, simulations and modelling systems will feature prominently in the development programme. It is planned that the training of a number of educational software authors will be a feature of this task; an aspect which will draw on the experience of a previous Anglo-German educational software author training project [11].
- Task 3 is to develop a data-exchange system concerned with river pollution, with data exchange between a number of centres located in various parts of Bulgaria. Data are being collected using the Global Rivers Environmental Education Network (GREEN) [12] parameters and the BACH parameters [13]. This exchange of data will lead to a national database on river pollution. The curriculum revision in Task 1 will make use of this database to develop exemplar teaching materials.

The structure and tasks of the project are shown in Fig. 1. Activities are shown on the left, resulting tasks are shown in the centre, and the outputs of the project are shown on the right and at the bottom.

Task 1

The curriculum development associated with this task is being completed with extensive reference to the collection and analysis of river pollution data. A pilot scheme has been established, with developments based on work in a number of subject areas. Table 1 gives details of this pilot scheme.

Two information-handling packages have been identified to support the analysis of the river pollution data. The first of these is *Bioview* [14, 15]. This is a data-handling package which uses a novel pictorial database representation to facilitate the creation and exploration of databases that involve three interacting variables. Each of the three variables is presented by the axis of a cuboid, creating three orthogonal sets of datasheets. Each of these sets can be selected for inspection by choosing an appropriate face of the cuboid. Graphs and tabular data for rows and columns in a selected sheet (which will feature two of the variables with the third variable fixed) can be requested. By successively selecting datasheets, a graph of a row or column can be animated to give a feel for the way in which the data in the row or column changes as the third variable changes. The second information-handling package is *Umweltatlas* [16, 17]. This is a data representation software tool which allows data to be stored with reference to maps of areas corresponding to the data collection zones. These data can be interrogated according to specified coordinates, with the results displayed in a variety of forms, e.g., bar-charts and line-graphs. Illustrative material such as textual descriptions, pictures and diagrams are included in the software.

Water pollution data for the Iskar, Russensky Lom and Struma rivers, which have been collected by the Bulgarian Ministry for Environmental Protection on a monthly basis for the last three years, is being used to support curriculum development in

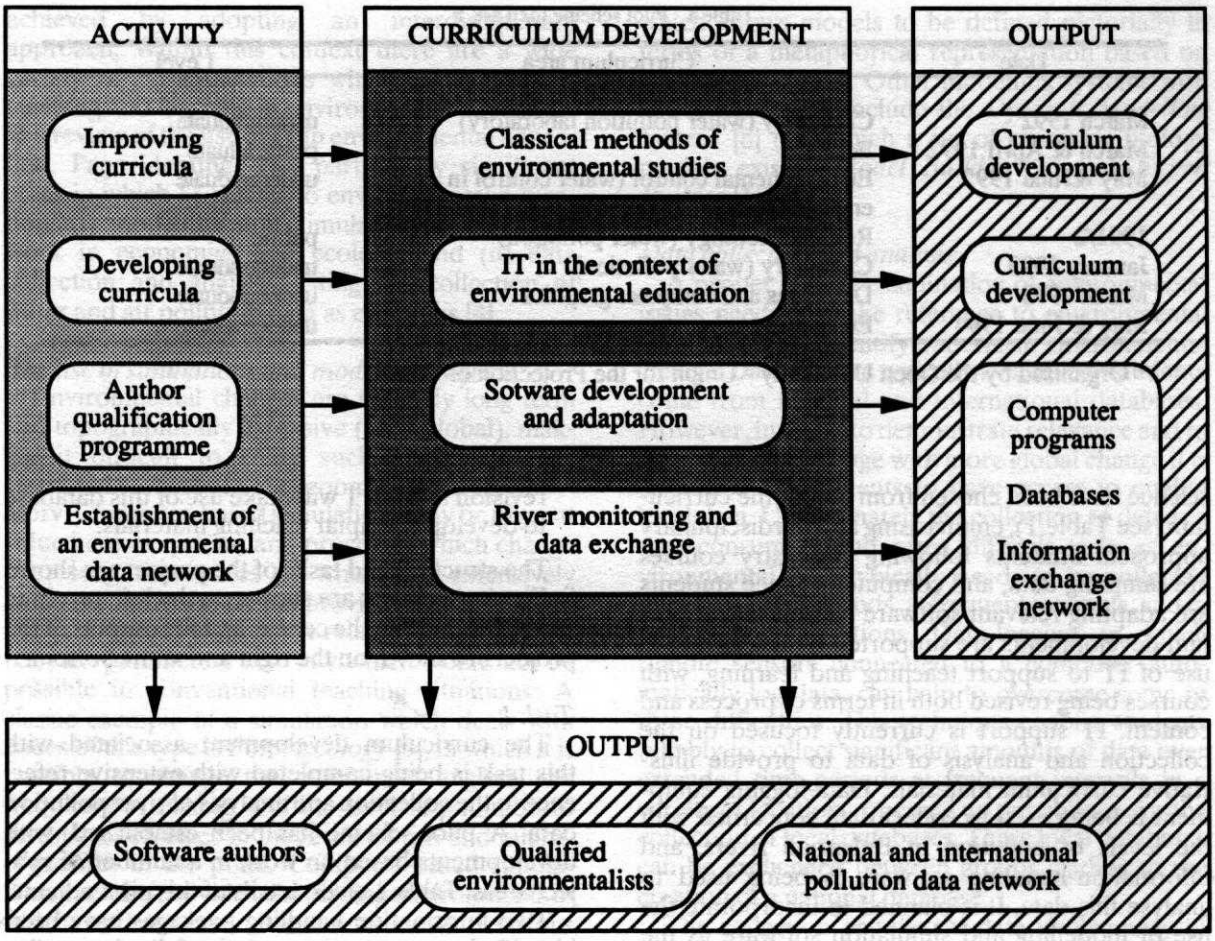

Fig. 1. The structure of the COBES project.

Task 1. These data correspond to seventy parameters, which include both the GREEN parameters and the BACH parameters. Data corresponding to these collection parameters is being extracted from the ministry database for use with *Bioview* and *Umweltatlas*. It will then be possible to use retrospective and current ministry data together with current data collected through the COBES project to examine trends in pollution.

Task 2

Bulgarian versions of *Bioview* and *Umweltatlas* are being prepared. *Bioview* is written in the Microsoft Windows operating system, with program-specific screen text stored in a resource file. This design makes the development of a Bulgarian version rather straightforward: by editing the resource file to replace English text with Bulgarian equivalent text, a Bulgarian version is produced for use with a Bulgarian version of Windows. *Umweltatlas* is written in Linkway, a hypermedia system featuring both text and graphics. The Bulgarian version of Linkway has been purchased and this is being used to prepare a Bulgarian version of *Umweltatlas*. This version will incorporate maps and information relevant to Bulgarian rivers. File-transfer procedures which will enable the transfer of data stored as DBASE III files to *Bioview* and *Umweltatlas* are being developed by students following the Databases and Computer Graphics course.

Task 3

Pollution data are being collected from three rivers: Iskar, Russensky Lom and Struma. In order to make the collection of these data a practical possibility two decisions have been made.

- The data collection framework established by the GREEN project has been used as an initial framework for the collection of data. This framework defines nine data collection parameters: dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, temperature, total phosphorous, nitrates, turbidity and total solids. In addition, the existence of representative microorganism are used to give a broad classification of water quality. It was recognised that these parameters provide the framework for a limited data collection exercise, but it is considered that they would provide a realistically collectable dataset which will be of sufficient scope to support curriculum development. The pilot study experience gained with students working in the Chemistry (water pollution laboratory) course

has shown that there are practical difficulties in measuring the total solids concentration. This has prompted the decision to adopt the data collection parameters defined in the BACH framework, which uses the same parameters as the GREEN project with the exception of the total solids parameter. This parameter is replaced with the two parameters of ammonia concentration and electrical conductivity.

- Data-logging will be completed by using self-contained, purpose-designed environmental data collection kits. These kits contain all the necessary hardware and materials to collect data corresponding to the GREEN and BACH parameters. These kits have been manufactured and assembled in Germany and distributed to project members in Bulgaria.

DISCUSSION

An important feature of the COBES project is that it has adopted a proactive approach to the use of IT to support curriculum development, as illustrated by the development and use of data-logging to establish a national river pollution database. By ensuring that the pedagogic possibilities of using IT are considered as an integral part of the design of new curricula and the revision of existing curricula, the potential of IT to act as an agent for change may be realised, particularly through an emphasis on the introduction of a process-related approach to the curriculum. As the work of this project has demonstrated, this potential has considerable relevance to developments in environmental education. In fact, without the use of IT, many practices in environmental education, which are now commonly accepted, would be practically impossible or very difficult; the collection and analysis of local data, the formation and testing of hypotheses based on the extensive exploration of data, role-playing and decision-making all illustrate the power of IT to enhance environmental education.

COBES appears to be established as a successful venture. There is clear evidence that the three COBES tasks are being completed. A total of sixty students (in two groups) following the Chemistry (water pollution laboratory) course have been involved in testing the usefulness of the GREEN parameters as part of the initial pilot study, thus contributing to Task 1 and Task 3. Students following the Database and Computer Graphics course are involved with the adaptation of *Bioview* and *Umweltatlas*, thus contributing to Task 2. Although adaptations of software are proceeding, the author-training aspect of Task 2 has been deferred due to insufficient funding. It is hoped that future funding will allow this aspect of Task 2 to be developed. The aim of Task 3 to establish a network of participating organisations is becoming a reality; the participation of the Open University–Union for the Protection of Nature and contacts with the Ministry for Environmental Protection are clear evidence of this developing network. It seems that COBES is acting as an effective catalyst for instigated both curriculum reform and national debate about the environment and pollution. An indication of this success is the fact that another similar project (COBES-BALTIC) has been submitted for EC TEMPUS funding as from August 1992, with IPN and King's College collaborating with the University of Klaipeda, Lithuania and the University of Tartu, Estonia.

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