Unesco-UNEP International Environmental Education Programme

Environmental Educational Series **7**

Environmental Education: Module for Pre-Service Training of Science Teachers and Supervisors for Secondary Schools

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PREFACE

A series of experimental modules for the pre-service and in-service traning of primary-school teachers, secondary-school science and social studies teachers in environmental education has been prepared in the context of the Unesco-UNEP International Environmental Education Programme, and as a follow up to the Tbilisi Conference Recommandations with respect to the training of teachers in environmental education.

This module focuses on the pre-service training of science teachers and supervisors in environmental education for secondary schools. Its main objectives are to (a) foster the acquisition and transfer of knowledge, skills, and affective attributes concerning the environment and its problems and (b) develop competence in the teaching and supervision of the environmental dimension of science in secondary schools. In this context, the module addresses itself to (a) the environmental problematique and education's response, (b) science education - an essential contribution to environmental education, (c) curriculum tasks in environmental education for science teachers, (d) teaching strategies for use in environmental science education, (e) evaluation in environmental education, and (f) implementation of environmental education at the school and system levels.

The module for Pre-service Training of Science teachers and Supervisors in Environmental Education for Secondary Schools has been prepared under Unesco contract at Monash University and South Australian College of Advanced Education (Peter J. Fensham and D. John Hunwick). In the process of the preparation, the detailed outline and the different drafts of the module were circulated for comments and critics to about thirty professionals and institutions around the world. Similarly, the module and its local adaptation were studied by groups of teacher educators at the Subregional Workshops on Teacher Training in Environmental Education at the National Council of Educational Research and Training (NCERT), New Delhi, India, on 3-16 March 1983 and at the School of Education of the University of West Indies, Mona, Jamaica, on 18-29 July 1983. Unesco is appreciative of the contributions made which have been used towards the preparation of this version edited by Professor Willard J. Jacobson, Teachers College, Columbia University, New York, N.Y., U.S.A.

Opinions expressed in this publication do not necessarily coincide with any official views of Unesco. The designation employed and the presentation of the material herein do not imply the expression of any opinion whatsoever on the part of Unesco concerning the legal status of any country, or of its authorities, or concerning the delimitations of the frontiers of any country or territory.

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FOREWORD

This book sets out to help science teachers make science teaching more environmental. That is, it explores a number of ways that science teachers can contribute through their lessons with pupils to an improved environmental scene. We are very conscious that science education alone cannot provide all the education that is needed for environmental issues. The environment is not neatly parcelled up according to the subject labels of schooling. For this reason environmental education needs to have contributions from all subject areas of the curriculum and indeed needs to find ways of giving an interdisciplinary approach to students' learning.

We agree with these total intentions for environmental education and acknowledge that many environmental problems will depend upon complex economic, social and political considerations for their solution. Nevertheless, we know that secondary schooling in most countries is organised and presented through separate subjects. Not only is science a very important school subject, but there are also scientific aspects to most environmental issues.

It is important to say a word about our philosophical stance re environmental education. We see environmental education as a contribution to the solution of real problems.

It is part of a wider response to alleviate the threats that face so many aspects of Planet Earth's environment and that limit effective and harmonious living for so many of the world's population.

The goal of environmental education for us is Education <u>for</u> the Environment not merely education in or about the environment. These last two types of education may be useful stages towards the goal but they are not the goal itself.

Beyond the individual response, we see many of the problems of human and social development as part of the wider environmental scene. The disproportionate consumption and waste of both resources and energy by the minority population of the developed, industrial world are environmental concerns of the first order. So too is the lack of access of the majority population of the developing nations to these resources and to adequate energy sources.

We recognise that all human beings are actors in present day environmental dramas. While some people exert great influence on the present and future quality of the environment, the last decade has revealed that most people's lifestyles have adverse consequences. Because of this, individuals reading this book can, through their own lifestyle, contribute positively to the harmony and conservation of the environment. As people involved in education, they have the additional opportunity to influence the choice and development of some aspects of other people's lifestyles.

Advocating social action as the outcome of environmental education is consistent with our own commitment to social change if environmental issues are to be resolved. It is the responsibility of every teacher and science teacher educator to choose the manner, timing and extent of the involvement of students in environmental issues. While change in many aspects may be desirable, the educator's responsibility, as we see it, is to develop in students the feeling that they can participate in change and that this will be more effective when the science that is involved is properly applied.

The book is presented as a series of units for use in the education of science teachers. Its primary orientation is that it will be useful in the initial education of these teachers. Many of its units (or short sequences of them) could, we believe, also be used in in-service workshops for science teachers during their professional careers.

We have assumed that these science teachers will have had (or be having) a sound education in science as part of their basic training as teachers of this subject area of the curriculum. Because a few science concepts recur very often in environmental situations we have included in an Appendix some basic material on these which highlight the environmental linkage.

We also believe that education of science teachers should induct them into the sorts of learning experiences they should provide for their own pupils in schools. Accordingly we have given attention in many of the units (particularly Chapter 3) to the variety of modes that are known to enhance learning. These units, in particular, make the book also a source book of curriculum ideas for science teachers. In many educational systems, we expect that pupils taking middle and senior secondary science courses could, with profit, undertake many of these units. In adapting these units to their use in schools, teachers would need to recognize and allow for the constraints of their own situations. Chapter 6 of the book should be helpful to them in this implementation.

A secondary orientation of the book is to the supervisors in the educational system who have responsibilities about the way science is taught, and who can do so much to facilitate the efforts of science teachers in their classrooms. Chapters 1 and 6 are, we believe, particularly important for use with these sorts of educational professionals.

In revising an early draft of our manuscript we have been very much helped by the comments and suggestions of a number of reviewers. A list of these persons is given at the end of this preface and we wish to record our gratitude to them all. One particular advantage from these varied comments was that we were able to gain some broader perspective on the situations that exist for the education of science teachers. It is quite clear that these vary very greatly. Some reviewers felt that we had expectations that went beyond what would be possible in many developing countries. Another suggested that in meeting the needs of these countries we had pitched the content at a level that was more appropriate for senior secondary pupils in his country than for the education of their teachers.

Another reviewer wanted more structure and tight linkage to science topics. Against this there was a plea for a much more open ended approach in which real environmental issues would be tackled by the science teacher educator and his/her student teacher over an extended period of a year. In this approach, problem solving and its concomitant skills would be developed in the reality of the project.

Armed with all these and many other comments we have revised the draft and tried to cover as many situations as possible. We do acknowlege, however, that it will be the prerogative and the responsibility of experienced science educators, regional consultants and state and national supervisors to select and modify our suggestions so that they can be used with meaning and sensitivity in each particular situation.

Acknowledgements

Internationally we are indebted to the following reviewers - Abdul Ghafoor, Robert J. Warpinski, Gunter Eulefeld, Paul F. Norvale, Fred H. Hubbard, George Za'rour, Ron Morgan, Arthur M. Lucas and R. Kyburz-Graber.

Locally, Ian Walker, Ted Sandercock and Peter Brinkworth of the S.A.C.A.E. have played a similar role and we are most grateful for their many perceptive suggestions. Finally, there are those many students in our classes who have made and tested for us so many of the ideas that come together in this book. To them we express our thanks for they and others like them are the people for whom this book is intended.

Peter Fensham

D. John Hunwick

INTRODUCTION

The education of science teachers, like science education in schools, takes place usually in a series of discrete sessions - part of the timetable of a programme of formal education. Occasionally these sessions can be extended and commonly there is opportunity for the learning experience to be continued in the learner's unscheduled time. These patterns of learning apply also to the inservice situation where a programme of learning is drawn up for whatever period the teachers have been released from their classroom.

To facilitate the use of the ideas in this book in such learning patterns, it has been primarily presented in the form of units which are explicitly designed for discrete sessions.

The units, in general, have a common format that has already been found, in projects in a number of countries, to have widespread usefulness in science teacher education.

In setting out these units which show clearly the various components of learning sessions, we are conscious that the written word makes static a learning scene that in practice should be dynamic and interactive. Accordingly, users of this book are encouraged to familiarise themselves with the intention of each unit and implement it in a way that is flexible and meaningful to their students.

Included in the introduction to each unit there are a summary of its ideas, suggestions for its implementation, and a clear statement of a unit's objectives. These form a basis for the teacher educators and pre-service teachers to evaluate the effectiveness of their performance in a unit as well as the worthwhileness of the unit's ideas. Where necessary in the suggested approach, a Worksheet is also provided for easy reproduction and possible use in the training programme.

In general, it is assumed that the training of science teachers will be the responsibility of a single person (or a group of such persons) to whom we refer by the term science teacher educator.

The resource materials that are involved in the units have been deliberately chosen so that they have a wide adaptability across countries and educational systems. Since the specific materials will often have to refer to environmental situations that have meaning locally, attention is given to the provision of examples and likely sources.

The basic time for a teacher training session is assumed to be one hour. Some units will take multiples of this time or involve a sequence of hour sessions over a period of time in the training course.

In planning and preparing the units for this book we have had a number of broad objectives in mind. These are

(a) To alert the student science teachers to the urgency of the Environmental crisis.

(b) To present the origins of Environmental Education.

(c) To provide a rationale for, and a sense of urgency for Environmental Education in Science and other teaching.

(d) To define a set of characteristics or guidelines for Environmental Education.

(e) To indicate the relation between science teaching and Environmental Education.

(f) To establish a list of objectives for Environmental Education in science teaching.

(g) To promote problem solving as the central feature of Environmental Education in science teaching.

(h) To provide some basic concepts that are useful in Environmental problem solving.

(i) To identify and acquire skills in the various stages of curriculum planning for Environmental Education in science classrooms.

(j) To know and to experience teaching strategies that are particularly useful in Environmental Education.

(k) To recognise criteria and to practice using them in the evaluation of Environmental Education.

(l) To identify and reduce the factors that constrain the teaching of Environmental Education by teachers and to provide the conditions and support for teachers that may facilitate its implementation.

As a result, the units group themselves rather naturally into six Chapters. In Chapter 1 (Units I to IV), the student science teachers are introduced to the origins of Environmental Education as a response to the urgent environmental problems that confront humankind at local, national and global levels. The nature of this distinctive and purposive type of education is then developed via its objectives and particular characteristics. In clarifying environmental education its features will be contrasted with those of traditional science teaching (and that of other subjects) in secondary school. The chapter concludes with a unit that develops a schema for science teachers to include an environmental emphasis in their science teaching and to recognise this as a contribution to the totality of Environmental Education.

Chapter 2 (Units V-VIII) deals with the nature of science, its relationship to environmental education, and some of the concepts already developed through science that relate to the environment.

Science often means different things to different people. To many it means bodies of knowledge about the physical world grouped under different subjects; to some it means research or the pursuit of truth; to some it means the development of technology intended to benefit mankind; and to others it means finding out, experimenting, measuring. These are all different aspects of science, as the knowledge, experimenting, technology, etc., have all been produced by what could be called the "processes of science".

The various "processes of science" are identified and summarised in the first part of this chapter as an introduction to that characteristic of science - the problem-solving approach - that is to be applied to an environmental issue. The processes that will be discussed include: observation, communication, control of variables, experimenting, hypothesising, measuring variables and concept formation.

Collectively the names of these processes of science make up a set of statements that formally describe the process of problem-solving as used consciously or otherwise by scientists. It is through the application of these processes that scientific work is undertaken. The problems to which science addresses itself range very widely, e.g. from understanding the movement of particles in a fluid to the production of machines that will generate electricity. Environmental problems are just one aspect of life to which science can be applied, but they are, as we will argue, quite urgently in need of solution.

Because environmental education seeks to 'provide students with opportunities to be actively involved ... in working towards the solution of enviornmental problems', the problem-solving approach of science is an integral part of it. However, the problem-solving aspect of science has frequently been lost in science teaching, because of the overwhelming emphasis many teachers give to the exposition and acquisition of the body of knowledge in a text book, generally because it is required for a written examination. The acceptance of the goals of environmental education by science teachers, will therefore broaden their pupils' view of science by assisting them to become actively involved in its application as problem-solving.

Some science concepts have been defined and developed in ways that make them particularly relevant in the solving of environmental issues. A summary of six of these environmental concepts is presented in Appendix 1. Proper appreciation of them by teachers and pupils, however, comes not just from memorising them but from understanding their relevance and how they can be applied to significant environmental problems. Suggestions for teaching the concepts in preparation for tackling environmental problems are also given.

The concepts that are included are 1. Energy (types of energy, law of conservation of energy, and law of energy degradation); 2. Ecosystem (energy flow in ecosystems, law of conservation of matter, nutrient cycling in ecosystems, evolution of ecosystems and succession); 3. Resources (the nature of resources (inexhaustible, renewable, irreplaceable)); 4. Food (production, and energy use, and nutrition); 5. Pollution (pollutant, threshold, synergy, persistence, and biological magnification); 6. Human Population - Growth and Control (birth rate, death rate, fertility rate, marriage age, age structure and density, and distribution.

Chapter 3 (Units IX-XIV) consists of a number of units that collectively consider in detail the curriculum task a science teacher has if she/he is to implement an environmental emphasis in the classroom.

Six stages of the teacher's curriculum plan are identified and elaborated: -

(i) identifying an environmental "problem" area.

(ii) investigating a problem (identifying and acquiring the relevant background knowledge that is to be used by the class).

(iii) preparing and evaluating possible solutions to the problem.

(iv) getting involved.

(v) identifying possible strategies for social action by the class and teacher.

(vi) evaluating the strategies for social action.

The chapter then includes an exemplary environmental situation (the problem of waste disposal) that has very evident scientific or technological features and that will be familiar in almost all countries.

In order to implement the curricula tasks outlined, a number of teaching strategies that are particularly useful for Environmental Education in classrooms are introduced experientially to the science teachers in the suggestions in the Units of Chapter 4 (XV-XVII). As examples we cite here "buzz groups" and "brainstorming". The former is an activity requiring a class to be divided up into small numbers of pupils (2-8) following a short talk or other presentation of a limited task. The pupils carry out the required task having been given a short period of time (e.g. 4-5 minutes) following which there is feedback to the teacher and the whole group. "Brainstorming" is the use of a number of "brains" to throw up ideas quickly, <u>without</u> evaluating them, that could contribute to the solution of a problem. Again a limited period of time is given (10-15 minutes). Other teaching strategies included are the use of audio visual and other non-verbal stimuli, debates and projects, simulation and other games. Special units are devoted to the use of role playing and simulation, the conduct of a field trip, and the development of the learning trail.

Chapter 5 (Units XVIII-XX) looks at evalutaion in environmental education in a number of senses. One of these uses a form of content analysis to provide evaluations of curriculum materials like text books and other student resources. Curriculum resources of these types are slowly becoming more available to science teachers in many countries, but there are still many problems with these supports to teachers. Effective environmental education will need to be related to local, topical and current situations much more often than to the most distant, chronic, and exemplary situations that can be included in large scale and permanent curricular resources. Furthermore, we should not expect that environmental resources produced in one country will be of much use in the schools of another one. Traditional science text books have often had considerable portability of this sort although more recently the need to embed science teaching more strongly in a nation's own cultural scene has been recognised.

Accordingly, the resources science teachers will use in environmental teaching will often be newspaper articles, information from both expert and lay participants in environmental issues, and locally obtained statistics and data. They should use these in various ways in lessons, and a way of checking what sorts of teaching and learning experiences in fact are being used is presented at the end of this chapter.

Chapter 6 is concerned with the support science teachers need from their school authorities and in the wider educational system itself if they are to be able to contribute environmental education through their science lessons.

Equipping the science teacher with the concepts of Environmental Education and with the skills and strategies for its design and teaching is only one of the requirements for the implementation of Environmental Education in schools. All educational systems have constraints that hinder innovation in curriculum and teaching. The identification and control of these constraining factors are important if teaching is to become more environmental. Some of the constraints are quite beyond the control of the classroom teacher. It is in relation to this latter type of constraint that the science supervisors have quite key roles. Through them, constraints on the teacher and the school can be lifted, and conditions created that make possible some of the novel but quite essential features of Environmental Education. It is thus most important that science supervisors be aware of their role concerning these constraints and facilitating conditions. These will, however, be very different from country to country and the co-operation of supervisors will be needed to adapt the chapter's issues to the particular situations they are in.

The discussion in this chapter deals with these support structures for Environmental Education at three levels - within the school, the system, and the community. Within the school the constraints may take the form of timetable difficulties, opposition from other staff, conflict with traditional teaching approaches, lack of understanding and encouragement from senior administrators, conflict with student expectations, lack of resources, etc. Within the system they may come from an overcrowded curriculum, a dominant and unsupportive examination system, and from legal and financial difficulties re field trips. Within the community they may relate to the involvement of outside resources, cumbersome administrative procedures, and parental and community participation.

In discussing these sorts of constraints teachers and supervisors will be encouraged to identify which ones exist in their own cases and how they can work to modify them so that strucutres emerge that support the teacher in his/her classroom.

Environmental Education within Science Teaching

We recognise that there is little scope for self-determination in the overall secondary school science curriculum by the individual science teacher. Science curricula in most countries (except perhaps for the lowest levels of the secondary school) are laid down by the Ministry of Education and/or by Examinations Boards.

Accordingly, our major thrust in the book is towards the teaching of Environmental Education, from time to time, in the science class through the existing curriculum of science education and through special events or "junctions". A special event might be an excursion, a display, a community work project, a school project or a festival. The word "junction" is used (as at the Unesco Asian Workshop for Environmental Education in September, 1980) to describe such occasional happenings in a class or school programme and is useful because it does imply the co-operation or "coming together" of the science teacher with other teachers or with personnel from outside the school. This is necessary to embody the interdisciplinary, holistic and realistic characteristics of Environmental Education. We are not advocating or preparing science teachers for a new and separate subject - Environmental Science or Environmental Studies. Such an approach is not possible in most cases of secondary education since the curriculum is already overloaded. Furthermore it is not advocated as desirable since environmental education then becomes just one more specialised subject that is often only optional for students and hence has a rather low status.

This way of introducing Environmental Education is consistent with the recent moves for science teachers to include aspects of Science and Society in their science teaching. Science teachers are certainly concerned in Environmental Education about the interface between scientific knowledge and society, but the characteristics of Environmental Education add dimensions and significance about this interface that have not often yet been included in the socialising of science with its emphasis on description and analysis.

The book, as it has been written, is a package for use with science teachers as a part of their pre-service training course after they have been introduced to the basic aspects of the theory and practice of teaching science subjects. We recognise that it will perhaps often not be possible for the set of units to be included in teacher training in total or with all the detail that is provided. However, it is important that this book with its units be assimilated as a whole by science teacher educators before they seek to use it in their courses. Of particular importance are Units III, IV and V. These are designed to help science teachers deal with the nature of Environmental Education. Without a clear appreciation of its distinctive objectives and characteristics, science teachers are likely to believe that teaching the details of biophysical environments in their usual knowledge-only sense is Environmental Education. This would deny the fundamental purpose of the module.

CHAPTER 1

THE ENVIRONMENTAL PROBLEMATIQUE AND EDUCATION'S RESPONSE

INTRODUCTION

In the decade 1968-1978 the number of pesticide-resistant species of insects and mites has almost doubled.

Between 1960 and 1971 Japan lost 7% of its agricultural land to buildings and roads.

In India there is an annual loss of about 6,000 tonnes of soil per year and with this goes six million tonnes of nutrients - more than the amount added as fertiliser.

In the United States three million acres (nearly 1% of the agricultural land) is degraded annually by soil erosion.

Overstocking has severely degraded grazing lands in North America, in the Andes and even in the Himalayas.

Traditional strains of crops and animals are seriously at risk. Of the 145 cattle breeds native to Europe and the Mediterranean, 115 are threatened with extinction.

Nearly one quarter of the earth's land surface is in danger of becoming desert.

The average Swiss citizen consumes forty times as much in resources at the average Somali.

Despite its small population, most of Australia's coastal forests have been destroyed, there are threats from logging to the few remain-areas.

A widespread problem in Sri Lanka is the cutting of mangroves for firewood.

The Bay of Mieggia in the northern Adriatic has been devastated by petrochemical wastes.

After the publicity that followed the disastrous Minamata Disease, many fish and shellfish in Japan still have too high levels of mercury.

Tourism, sewage and fertilisers, are destroying coral reefs in Tanzania, Australia and the Virgin Islands.

I.U.C.N.'s Red Data Book lists more than 1,000 species know to be threatened with extinction.

These staccato comments are drawn from Robert Allen's little book How to Save the World.* This book sets out to publicise the

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* How to Save the World: strategy for world conservation, Robert Allen, Paul Keagan, London, 1980.

World Conservation Strategy - a challenge to governments to recognise that the needs of the world's people as a whole, and the improvement of their quality of life will only be possible through the dual processes of development and conservation.

The purpose of such a Strategy, nationally and internationally, is to help advance the achievement of sustainable development through the conservation of living resources.

Because of its emphasis on living resources, this strategy does not highlight so strongly a number of other issues such as the disproportionate consumption of energy by the citizens of the quarter of the world that is sometimes described as developed and is perhaps better described as industrial. These persons also consume far more per capita of the mineral resources, some of which have been so depleted that an end to their availability is now within a generation or two unless new reserves are found or more conservative procedures are introduced.

Our activities as humans are steadily reducing the capacity of the earth to go on sustaining life. One quarter of the world are consuming too rapidly while half of the world, in order to stay alive,have to engage in practices which, while under consuming in comparison, are destructive of the basic land and water around them.

The sorts of problems and issues that have been alluded to above are what has become known internationally as the Environmentale Problematique. Essentially this situation has arisen as a consequence of increasing human demands on finite resources. The demands come from many sources of human life but two quite different developments in this century have made the situation a critical problem now, in ways it was not fifty years ago. The first development has been the rapid escalation of the living standards of much of the population of the more industrialised countries since 1950. As these mass living standards have risen, their consumption of resources has gone up many times. The other developemnt that has so affected the other 75% of humanity has not been a rapid increase in their per capita consumption of resources, but a very significant increase in their overall population growth.

So we have two populations whose lifestyles are probably getting further apart. One is static in size, but consuming increasing amounts of resources and the other, also consuming more, but only because it is increasing in size. The lifestyles of the former are not however invisible to the latter and it is not surprising that they too have aspirations for greater consumption per capita. For both groups then, there is a contradiction between aspiration and possibility.

Another difference between these populations arises when the quality of their living environment is considered. In the population of already high consumption, improved quality of life or quality of living environment is often thought of in very individualistic terms. The things this person has, the style of house he or she lives in, and the types of leisure pursuits that can be afforded are often the sorts of measures that might be applied. In the case of the low consuming population one tends to think of the whole community's or society's lifestyle or environment. The general inadequacy of shelter, the poor standard of nutrition, the absence of suitable sanitation, the unavailability of fuel and other resources, are the natural measures, and these are social or group and not individual ones. The subtlety of this shift of measure is an important thing to be aware of in the whole environmental movement. Many persons strongly involved in environmental issues in the developed world may be motivated to preserve or improve an already "good" environment. In the other populations, such "good" environments have not yet existed and need to be achieved. The task of being "for a better environment", is rather different in these two cases. As we look more and more at education for the environment in this book rather than just education about the environment, it is important to note these points and remember some of these differences which are themselves very much part of the Environmentale Problematique.

How is it that we have this internationally recognised problem, and where have the initiatives for things like a World Conservation Strategy come from?

In 1972 the United Nations held a conference in Stockholm on the Human Environment. The participation in this meeting and the response to it was quite extra-ordinary.

The conference provided the first really international opportunity for the voices of concern about the sorts of issues at the beginning of this chapter to be raised. Persons from all sorts of countries were among the voices at Stockholm. Each from their own expertise pointed to the contradictions they had found in the way human beings were developing and the ability of Planet Earth to sustain indefinitely that pattern of development. Many of the sorts of examples that began this chapter were given at Stockholm. It was like taking the lid off an international pot that had not previously been opened. Not everything inside could be seen at once but enough was evident for the world body to be convinced that urgent action was needed.

A new international agency, the United Nations Environment Programme, UNEP was established and a number of other bodies like the International Union for the Conservation of Nature and the World Wildlife Fund got new recognition of their efforts and importance.

The United Nations Educational Scientific and Cultural Organisation, UNESCO, was asked to work with UNEP to create an international and national contribution from education to the solution of these great problems. Since major changes in lifestyle and complex biophysical systems were involved education obviously had much to do. This book is one small product of the multi-faceted educational response to the challenge that was issued at Stockholm and which is renewed almost daily in all countries of the world as we learn more of the contents of that pot of problems that involve our local, national and world environment.

One useful way to categorise the problems within the Environmentale Problematique has been the five broad headings of Ecology, Energy, Population, Food and Resources. These will be used on a number of occasions in the units of this book. The first of these units sets out to assist its learners to begin to appreciate the extent and pervasiveness of environmental issues and to recognise how human beings are involved in both their causes and their effects.

UNIT 1: The Nature of Environmental Issues.	
<u>Objectives</u> (1) to enable students to recognise and classify environmental issues (2) to help students identify these issues at national and local levels (3) to demonstrate that these issues can also be identified in the social and physical environment of a school (4) to identify some of the human interactions in these issues	<u>Environmental Education Aims</u> . to help students acquire an <u>awareness</u> of and <u>sensitivity</u> to the total environment . to help students develop a basic <u>understanding</u> of the total environment and the interrelationship of man and the environment <u>Science Process Skills</u> interpreting data, communicating, classifying <u>Pedagogical Techniques</u> Buzz groups, small group activity assignments, data collection.
<u>Preservice Teacher Needs</u> (1) to become aware of a wide range of environmental situations that may have educational potential	(2) to be able to identify in broad terms environmental issues in different contexts
<u>Resources</u> Newspapers and Worksheet.	<u>Suggested Time</u> One 2-hour session

SUGGESTED APPROACH

Introduce the pre-service science teachers to the five broad headings of environmental concern - Ecology, Energy, Population, Food and Resources by using some of the <u>situational statements at the beginning of Chapter 1</u>. Check that this introductory process has provided the class with some appreciation of the meaning of these headings as a classification for environmental problems.

The class should then attempt to classify the other items on the Worksheet. After a few minutes, suggest that they discuss their classifications in small groups. Some of the items will probably have multiple positions in the classification.

ACTIVITY 1 - Identifying Environmental Issues

The class could then be re-grouped into small groups of five or six pre-service teachers and each group asked to undertake the next task on the Worksheet.

Type of Issue	National	Local or Regional	School Context
Ecology			
Energy			
Population			
Food			
Resources			

The task for each group is to try (from their own experience, general reading, and expert knowledge) and find one or more examples of environmental issues that could be located in each part of the matrix on the Worksheet. In other words the questions for the groups are: -

(i) What is an example of an Ecological issue in our country?

(ii) What is an example of an Ecological issue that is specific to a local area (or region) with which I am familiar?

(iii) What is an Ecological issue that exists in many schools in our country?

and so on for Energy, Population, Food and Resources.

If the pre-service teachers seem to be slow in coming up with examples, the science teacher educator may help them along by suggesting that endangered species and pollution are sub-categories of the Ecology heading, that sources of, and comparative rates of consumption are environmental issues within Energy, that growth rates, age profiles, and employment patterns are Population issues, that relative protein intakes, food self-sufficiency, food distribution and food quality, are recurring issues within Food in both developed and developing countries, and finally that where iron, copper, chromium, phosphate and the manufactured goods used in home, industry, the farm and the school come from and go after use raise Resource issues.

ACTIVITY 2 - Recognising Human Interrelationships

When a number of the parts of the matrix are completed, one example from each line or column should be chosen by the group and a list made of the types and groups of persons who are involved in this issue. The following check-list of questions may be helpful:

(i) Whose interests and needs are met in this situation?

(ii) What groups are actually directly involved in this situation?

(iii) Which groups' quality of life is, or may be adversely affected by the continuance of this environmental situation.

The small groups should be asked to report their identification of these human interactions in one of their environmental issues to the whole class in the last 15 minutes of the session.

Further Notes

If some more time is available for this unit or if it can be prepared for in earlier weeks, the following activities are suggested for action by either the science teacher educator or by members of the class of pre-service science teachers.

Because of the importance of keeping the reality of environmental problems in the forefront of any educational programmes, two other suggestions are made to science teacher educators in relation to the aims of this unit.

ACTIVITY 3

Keep a record of any issues that are reported in the newspaper (over say four weeks) and that seem to have an environmental aspect. See which of the broad headings most often appears and report their occurrence to the class.

If a library is available with the newspaper of 10 or 20 years ago, some of the class could be asked to go through a similar period of weeks to see if reporting of these sorts of issues has changed.

ACTIVITY 4

From sources like local authorities and other specialist sources of information (Wildlife Departments, Purchasing managers, Energy Companies, Census data, Sewage and garbage authorities, Industrial managers), some specific data can be gathered to indicate trends over the last decade in issues like the following:

What species of animals or plants are now more or less endangered in our country or region?

What features of the man-made heritage have been saved or lost, or recognised in this period?

What were and are the relative importance of oil, coal, wood, hydro and solar as sources of industrial and domestic energy?

What was and is the per capita consumption rate of energy per year?

Which of the sources of energy are imported from other countries?

What was and is the population growth rate?

What was and is the age profile?

For what sub-groups in the country do these population statistics vary considerably from overall national values?

For what types of food is the nation self-sufficient?

Has the incidence of indices of malnutrition and/or poor diet diminished or grown?

What minerals are now imported that previously were available in the country?

What fertilisers are being used commonly and how much of them are being imported?

What was and is the estimated rate of soil loss?

What is and was the per capita rate of production of solid waste?

What has changed (if at all) in the pattern of solid waste disposal?

The data that relate to these questions should be tabulated and shared in the class so that some sense of the stability or acceleration or recession of these potential environmental problems is gained.

The organisation and difficulties involved in gathering these data and presenting them in a meaningful way should be then considered by the class and classified as to their suitability for replication with the science students at the different levels of secondary school.

UNIT 1

THE NATURE OF ENVIRONMENTAL ISSUES

WORKSHEET

Classifying Environmental Situations

Ecology, Energy, Population, Food, Resources

Situation	Classification
In the decade 1968 - 1978 the number of pesticide-resistant species of insects and mites has almost doubled.	
Between 1960 and 1971 Japan lost 7% of its agricultural land to buildings and roads.	
In India there is annual loss of about 6000 million tonnes of soil per year and with this goes 6 million tonnes of nutrients - more than the amount added as fertiliser.	
In the U.S.A. three million acres (nearly 1% of the agricultural land) is degraded annually by soil erosion.	
Overstocking has severely degraded grazing lands in North Africa, in the Andes and even in the Himalayas.	
Traditional strains of crops and animals are seriously at risk. Of the 145 cattle breeds native to Europe and the Mediterranean, 115 are threatened with extinction.	
Nearly one quarter of the earth's land surface is in danger of becoming desert.	
The average Swiss citizen consumes forty times as much in resources as the average Somali.	
Despite its small population, most of Australia's coastal forests have been destroyed, and there are threats from logging to the few remaining areas.	
A widespread problem in Sri Lanka is the cutting of mangroves for firewood.	
The Bay of Mieggia in the northern Adriatic has been devastated by petrochemical wastes.	
After the publicity that followed the disastrous Minamata Disease, many fish and shellfish in Japan still have too high levels of mercury.	
Tourism, sewage and fertilisers, are destroying coral reefs in Tanzania, Australia and the Virgin Islands.	
I.U.C.N.'s Red Data Book lists more than 1000 species known to be threatened with extinction.	

ACTIVITY 1: Identifying Environmental Issues

Write in the squares of the matrix examples of the five types of issues that relate to the local school, local or national contexts.

Type of Issue	National	Local or Regional	School Context
Ecology			
Energy			
Population			
Food			
Resources			

ACTIVITY 2: Recognising Human Interrelationships

Choose a number of issues from the matrix and for each discuss the questions:

(i) Whose interests and needs are met in this situation?

(ii) What groups are actually directly involved in this situation?

(iii) Which groups' quality of life is, or may be adversely by the continuance of this environmental situation?

UNIT II

THE ENVIRONMENTAL CHALLENGE TO EDUCATION

INTRODUCTION

Environmental education in almost every country of the world has been to some extent affected by the International Programme of Unesco and UNEP. Such an influence from the work of Unesco cannot be claimed in many other areas of education especially in the more developed world.

The International Programme's influence in environmental education has been so strong because very few countries had developed this part of their educational programmes to any extent before the Unesco-UNEP project began in 1974. This was equally true of developed and developing countries.

There were, of course, many individuals, groups and interested organisations who were active in an educational sense prior to this time. Nevertheless, a survey that began the international project revealed few examples of countries where a general priority was being given in formal or in non-formal education to environmental education, or where extensive human and material resources, of an expert kind were available for it.

The first phase of the International Programme ran from 1974 to 1977. Among its achievements can be listed:

(i) an awakening of many countries to the need for and the possibilities of environmental education.

(ii) an evolving understanding of the nature of environmental education.

(iii) the acknowledgement at governmental levels that environmental education was important and should be developed and supported.

Since then the programme has moved into its second and third phase. In these years a great deal of development and some implementation has occurred in many countries. New curriculum materials have been developed, curriculum plans have been formulated, a great deal of inservice education has begun and a range of support services have been established in some countries.

The Unesco-UNEP International Environmental Education Programme (IEEP) has supported a number of these developments and through a continuing series of regional and international meetings, conferences and workshops has done much to facilitate the growth of ideas and the exchange of enthusiasm and worthwhile practices. Its newsletter CONNECT regularly sends news about environmental education all around the world.

This unit aims to enable preservice science teachers to share in the excitement and challenge that so characterised the first phase of the International Programme.

UNIT II : The Environmental Challenge to Education	
Objectives (1) to make students aware of the international nature of environmental education (2) to clarify the way human actions are responsible for the environmental problematique (3) to present the magnitude of the task facing environmental education (4) to indicate some of the many resources that now exist to support environmental education	**Environmental Education Aims** . to help students acquire social values involving strong feelings of concern for the environment. . to help students acquire the motivation to actively participate in environmental improvement and protection. **Pedagogical Techniques** teacher directed discussion, debate preparation.
Preservice Teacher Needs (1) To enthuse them with the idea of environmental education as a buoyant and contemporary movement (2) to reassure them that many resources are emerging to assist them to teach environmentally	
Resources 2 Worksheets, Copies of The World Conservation Strategy of the International Union for the Conservation of Nature would be very useful.	**Suggested Time** Two sessions of 1-1½ hours, followed up by personal reading of some of the resources displayed.

SUGGESTED APPROACH

ACTIVITY 1:

Members of the class should all be issued with Worksheet 1 which includes a copy of that part of the Belgrade Charter entitled "A. Environmental Situation". They should be encouraged to read it carefully several times as a whole and then to mark in the margin against lines in the text where it refers to: -

(a) applications of science and technology.

(b) the interactive effects of humankind on the natural environment.

(c) the interactive effects of some nations on other nations.

(d) the interactive effects of groups within a society on other groups.

(e) the types of behaviour that require change.

(f) the new types of behaviour that are sought.

(g) the qualities that may lead to the change in (e) and (f).

(h) features that define 'quality' of life.

ACTIVITY 2:

When the class members have become familiar with this early statement that was hammered out at the Belgrade Workshop of the International Programme in 1975, it could be divided in two halves, as if in a debate, to prepare arguments in support of the two views that people tend to hold about the conservation of the environment. The World Conservation Strategy of the International Union for the Conservation of Nature would be a useful resource for this task.

View A: The essence of the Environmental Problematique facing our nation (and the world) is the preservation of aspects of the man-made and natural environments that are under threat.

View B: The essence of the Environmental Problematique facing our nation (and the world) is more responsible and equitable development that includes a redistribution and a conservative approach to resources.

In making a list of the arguments on Worksheet 2 that support these two views, the two groups should also try to answer the following questions: -

a) With what sorts of resources and issues is this view usually associated?

b) Which groups (more affluent or less affluent) tend to be the most concerned about these issues?

c) Are these issues ones that directly affect the lives of the majority or the minority of a nation's citizens?

d) Whose living standards would be affected if this sort of environmental problem was solved?

e) Would the resolution of this issue in one country or region have negative repercussions on the quality of the environment elsewhere?

ACTIVITY 3:

A full page collage of headlines and items from various issues of CONNECT would serve as an initial resource for this activity in the second session. Such a collage is shown on Worksheet 3.

The students should study it to list the countries that can be identified from it as part of the environmental education movement.

Against this international backdrop the remainder of the time in this session would be usefully occupied helping the pre-service teachers become aware of the range of international, national and more local resources that exist for environmental education. If possible, some of the many Unesco and UNEP publications should be displayed. A list of these international sources is included in Appendix 4.

The science teacher educator should have on display for this session examples of national and more local resources, e.g. materials from Departments and Ministries of Education, Environment, Conservation, Energy, Health - Curriculum Materials - Publications, films, etc., from Non-Governmental Organisations - Reports from National Commissions for Unesco.

The intention for this session is not that the pre-service teachers learn any particular details about environmental education or these resources. Rather it is that they will realise that environmental education is an exciting international and national movement for which many resources exist.

Worksheet I

THE BELGRADE CHARTER

FRAMEWORK FOR ENVIRONMENTAL EDUCATION

A. Environmental Situation

Our generation has witnessed unprecedented economic growth and technological progress which, while bringing benefits to many people have also caused severe social and environmental consequences.

Inequality between the poor and the rich among nations and within nations is growing and there is evidence of increasing deterioration of the physical environment in some forms on a world-wide scale. This condition, although primarily caused by a relatively small number of nations, affects all of humanity.

The recent United Nations Declaration for a New International Economic Order calls for a new concept of development - one which takes into account the satisfaction of the needs and wants of every citizen of the earth, of the pluralism of societies and of the balance and harmony between humanity and the environment. What is being called for is the eradication of the basic causes of poverty, hunger, illiteracy, pollution, exploitation and domination. The previous pattern of dealing with these crucial problems on a fragmentary basis is no longer workable. It is absolutely vital that the world's citizens insist upon measures that will support the kind of economic growth which will not have harmful repercussions on people - that will not in any way diminish their environment and their living conditions. It is necessary to find ways to ensure that no nation should grow or develop at the expense of another nation and that the consumption of no individual should be increased at the expense of other individuals. The resources of the world should be developed in ways which will benfit all of humanity and provide the potential for raising the quality of life for everyone.

We need nothing short of a new global ethic. An ethic which espouses attitudes and behaviour for individuals and societies which are consonant with humanity's place within the biosphere - which recognises and sensitively responds to the complex and ever-changing relationships between man and nature and between man and man. Significant changes must occur in all of the world's nations to assure the kind of rational development which will be guided by this new global ideal - changes which will be directed towards an equitable distribution of the world's resources and more fairly satisfying the needs of all peoples. This new kind of development will also require the maximum reduction in harmful effects on the environment, the utilisation of waste materials for productive purposes, and the design of technologies that will enable such objectives to be achieved. Above all, it will demand the assurance of perpetual peace through the coexistence and co-operation between nations with different social systems. Substantial resources for reallocation to meet human needs can be gained through restricting military budgets and reducing competition in the manufacture of arms. Disarmament should be the ultimate goal.

These new approaches to the development and improvement of the environment call for a reordering of national and regional priorities. These policies aimed at maximising economic output without regard to its consequences on society and on the resources available for improving the quality of life must be questioned. Before this changing of priorities can be achieved, millions of individuals will themselves need to adjust their own priorities and assume a 'personal and individualised global ethic' - and reflect in all of their behaviour a commitment to the improvement of the quality of the environment and of life for all the world's people.

The reform of educational processes and systems is central to the building of this new development ethic and world economic order. Governments and policy-makers can order changes, and new development approaches can begin to improve the world's condition - but all of these are no more than short-term solutions unless the youth of the world receives a new kind of education. This will require new and productive relationships between students and teachers, between schools and communities, and between the education system and society at large. Recommendation 96 from the Stockholm Conference on the Human Environment called for the development of environmental education as one of the most critical elements of an all-out attack on the world's environmental crisis. This new environmental education must be broad based and strongly related to the basic principles outlined in the United Nations Declaration on the <u>New International Economic Order</u>. It is within this context that the foundations must be laid for a world-wide environmental education program that will make it possible to develop the new knowledge and skills, values and attitudes, which will constitute the key factor in a drive toward a quality of environment and, indeed, toward a better quality of life for present and future generations living within that environment.

Read carefully this statement several times trying to take in its overall emphasis and challenge.

Then read it again to find paragraphs and lines where it refers to the following. Use the left hand margin to insert lines as (a), (b), etc., and the right hand margin to similarly index the paragraphs.

(a) applications of science and technology.

(b) the interactive effects of humankind on the natural environment.

(c) the interactive effects of some nations on other nations.

(d) the interactive effects of groups within a society on other groups.

(e) the types of behaviour that require change.

(f) the new types of behaviour that are sought.

(g) the qualities that may lead to the changes in (e) and (f).

(h) features that define 'quality' of life.

<u>WORKSHEET 2</u>

<u>Environmental View A</u>:- The essence of the Environmental Problematique facing our nation (and the world) is the preservation of aspects of the man-made and natural environments that are under threat.

<u>Environmental View B</u>:- The essence of the Environmental Problematique facing our nation (and the world) is more responsible and equitable development that includes a redistribution of, and a conservative approach to resources.

Arguments in support of View ___ : -

1) ______________________________

____

2) ______________________________

____

3) ______________________________

____

(a) With what sorts of resources and issues is this view usually associated?

____

____

(b) Which groups (more affluent or less affluent) tend to be the most concerned about these issues?

____

(c) Are these issues (in (a)) ones that directly affect the lives of the majority or the minority of a nation's citizens?

____

(d) Whose living standards would be affected if this sort of environmental problem was solved?

____

(e) Would the resolution of this issue in one country or region have negative repercussions on the quality of the environment elsewhere?

____

WORKSHEET 3

A Collage of Headings and Places from Connect.

African Regional Workshop in Environmental Education

Dakar, Senegal, 11-20 December 1978.

Latin American Environmental Education Activities

São Paulo, Brazil, 26-31 March 1979.

Environmental Education in the Asia and Oceania Region

Latin American Regional Workshop in Environmental Education

San José, Costa Rica, 29 October-7 November 1979.

European Conference on Environmental Education

Berne, Switzerland, 29 March-2 April 1980.

Caribbean Workshop on Environmental Education

Antigua, 9-20 June 1980.

Teacher Training in Environmental Education

World Problems and Unesco's Medium-Term Plan (1984-1989)

Education and the Environment

Paris, 23 November - 3 December, 1982.

UNIT III

DEFINING ENVIRONMENTAL EDUCATION

INTRODUCTION

Over the years a number of definitions of environmental education have become available, and several of these are given in Appendix 3. However since the early 1970s they have all tended to emphasise similar points to those in the Nevada Conference of the International Union for the Conservation of Nature and Natural Resources:

> *"Environmental education is the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulating of a code of behaviour about issues concerning environmental quality."*

Some important features in this definition that will recur throughout much of this module are the following:

- Recognition of the inter-relatedness of mankind and the biophysical support systems in which human life occurs.
- A priority for learning values and attitudes as well as for learning more customary conceptual knowledge.
- A deliberate attempt to develop skills for real situations.
- A relationship between education and codes of personal and social behaviour.

It is important to dwell on these features that are so succinctly contained in 55 words. They are, in a number of ways, quite novel as far as definitions of school education are concerned. Indeed, they have more in common with the way we might define the education that took place, until the arrival of European colonists, in traditional societies among indigenous people like North and South American indians, Australian aborigines and the island communities in South-East Asia and the Pacific.

So many aspects of learning, for almost all societies, have now been handed over to schools, that they cannot be ignored or totally replaced when new programmes of education are needed.

Education has been challenged to make a contribution to the resolution of the world's Environmental Problematique. Accordingly, it is necessary that this very all embracing view of the process of environmental education be developed into broad goals or aims and detailed objectives for teaching and learning that can be related to schools and their forms of education.

During the 1970s, this development, at a general level, was undertaken. Sets of goals and objectives appeared as part of both the Belgrade and Tbilisi meetings and they are listed in Appendix 3 together with some from national curriculum statements. Again there is a remarkable congruence in the lists. This is a reflection of the influence of the international character of this educational movement.

The set of broad aims (goals) we have chosen for use in the module is as follows: -

. to help students acquire an awareness of and sensitivity to the total environment.

. to help students develop a basic understanding of the total environment and the interrelationships of man and the environment.

. to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems.

. to help students acquire social values and strong feelings of concern for the environment.

. to help students acquire the motivation for actively participating in environmental improvement and protection.

. to help students identify alternative approaches and make informed decisions about the environment based on ecological, political, economic, social and aesthetic factors.

. to provide students with opportunities to be actively involved at all levels in working towards the resolution of environmental problems.

These aims take the definition a little further by making more explicit reference to the problems to which environmental education is a response. They also spell out attitudes that recognise the urgency of the problems and they indicate that our inter-relatedness does mean there are alternatives for any environmental situation if enough citizens (or nations) will make the necessary decisions.

UNIT III: Defining Environmental Education	
Objectives (1) to help students elucidate the features of environmental education (2) to provide practice in applying these features to become familiar with them as a plan for environmental learning (3) to enable students to translate these general aims into specific objectives	Environmental Education Aims . to help students develop a basic understanding of the total environment and the inter-relationships of man and the environment . to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems Pedagogical Techniques small group work, teacher directed activity
Preservice Teacher Needs (1) to give students familiarity with the intentions of environmental education.	(2) to equip them with the ability to relate general aims to specific educational tasks.
Resources 3 Worksheets	Suggested Time 1 hour

SUGGESTED APPROACH

ACTIVITY 1:

The science teacher educator hands out Worksheet 1 that provides the class with the IUCN definition. The Worksheet also contains a circle and space around it as in Figure 1.1. The circle is a schematic representation of what the definition means by environment. The class is then asked to use the definition to write in the circle the components of the environment.

In the upper half of the space on the Worksheet around the circle, the pre-service teachers are then to write (from the definition) those things that environmental education is to develop in students concerning this environment.

In the lower half of the space around the circle, the pre-service teachers should then list those actions that environmental education is intended to lead learners to make when the quality of the environment is at issue.

The pre-service teachers should compare their diagrams and discuss their agreements and discrepancies. In particular, it is important that the meaning of "man" in the definition and where it should be represented in the diagram be considered, and the cases of individual "man" and societal "man be discussed.

The consequences of placing them inside or away from the circle contemplated since the separation of persons and some social groupings from their environment is associated with much of the exploitation of nature that has occurred throughout history.

ACTIVITY 2:

Worksheet 2 should now be handed out and the pre-service teachers can now read the list of aims for environmental education. By comparing the definition and their diagram on Worksheet 1 with the aims, the class are to consider how these two ways of describing environmental education are similar and different.

It is not necessary that only a one-to-one correspondence appears. A possible outcome would be:

Aim	Components in Definition
1	develop attitudes, appreciation, recognise values
2	clarify concepts, understanding
3	develop skills
4	appreciation develop attitudes
5	appreciation
6	decision making, code of behaviour
7	self-formulation

ACTIVITY 3:

The class should now be divided into groups of 4 or 5 and either are given a relevant environmental issue that would have some familiarity to them or are asked to choose one from their experience.

On Worksheet 3 they are now to try to formulate one or more specific objectives that link each of the seven aims to this environmental issue. It may be helpful to identify a level for this hypothetical educational programme. For example, it could be one in which the pre-service teachers themselves are the students or it could be lower or upper secondary students. However at this stage the emphasis is on the attempt to translate general aims into specific objectives rather than on their achievability in a real class.

When each group has finished, it should be encouraged to share and compare its list with another group particularly if they have worked from a common issue.

WORKSHEET 1

"Environmental education is the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and apprecitae the inter-relatedness among man, his culture and his bio-physical surroundings. Environmental education also entails practice in decision-making and self formulating of a code of behaviour about issues concerning environmental quality". (I.U.C.N. Nevada)

On the diagram below, list those things that this definition specifies as (i) the environment (in the circle); (ii) the things environmental education is to develop in learners concerning this environment (upper space outside circle) and (iii) the things environmental education should provide when the quality of the environment is at issue (lower half outside circle).

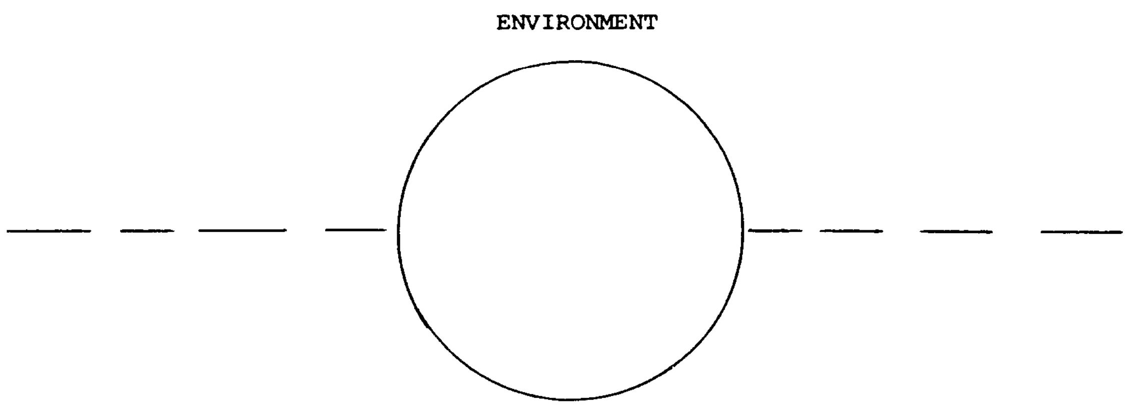

Figure 1.1 A schematic representation for the elements in the process of environmental education.

WORKSHEET 2

THE AIMS OF ENVIRONMENTAL EDUCATION ARE:

1. to help students acquire an awareness of and sensitivity to the total environment.

2. to help students develop a basic understanding of the total environment and the interrelationships of man and the environment.

3. to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems.

4. to help students acquire social values and strong feelings of concern for the environment.

5. to help students acquire the motivation for actively participating in environmental improvement and protection.

6. to help students identify alternative approaches and make informed decisions about the environment based on ecological, political, social and aesthetic factors.

7. to provide students with opportunities to be actively involved at all levels in working towards the resolution of environmental problems.

In the table below write in the right hand column the components of the definition on Worksheet 1 (that you identified in the upper and lower spaces) that relate to each aim.

Aim	Components in Definition
1.	
2.	
3.	
4.	
5.	
6.	
7.	

WORKSHEET 3

ENVIRONMENTAL ISSUE :

LEVEL FOR E.E. PROGRAMME :

General Aim	Specific Educational Objective in relation to this Environmental Issue
1.	
2.	
3.	
4.	
5.	
6.	
7.	

UNIT IV

SCIENCE TEACHING AND ENVIRONMENTAL EDUCATION

INTRODUCTION

The teaching of science now occupies a prestigious place in the total curriculum of secondary schooling. One hundred years ago science was fighting for a place in the then classically dominated school curriculum. Now, however, it is hard to imagine a secondary school without physics, chemistry and biology.

In the late 1950s and early 1960s when the attention of the developed world was turned to the role of schooling in providing an adequate supply of scientists and technologists, it was the science curricula of the secondary school that became the focus of reform. Since that time millions of dollars have been spent on projects that have produced many new approaches to the teaching of science.

The existence of these projects and the curriculum reform movement in science education does not mean that all the recommended changes have been adopted. The curriculum of schooling in many countries is not so easily modified. There are many constraints on and within the educational systems. External examinations, the traditional expectations of parents and employers, the use by society of science as a selecting subject, and the inertia of teachers, the lack of resources and adequate support for the innovations, are just some of the brakes on any hopes for rapid reform. Nevertheless there is little doubt in many developed countries that the scene of science education is much changed since the early 1960s. There has been a shift towards more active learning, the laboratory and the field have become more commonly the contexts for learning. Science syllabuses and courses contain more relevant content and a wider conception exists of what should be learnt in science classes at schools.

From the late 1960s a similar reform movement has been spreading in the countries of the developing world. The impetus for increased and improved science learning in these countries may be different from that which motivated the original developments in the U.S.A. and the U.K. There was certainly a strong degree of educational influence in the first spread of new science courses in the developing countries. A number of examples occurred where curricula designed to meet the specific educational needs of the U.S.A. and the U.K. were exported with only minimal adaptation to countries with very different needs. However, throughout the 1970s a number of more indigenous curriculum projects have appeared and some very significant changes are evident in science education in Africa, Asia and Latin America.

It appears that, overall, no other subject area in the school curricula has received such attention, and the character of science as a subject for study is well defined and reasonably familiar.

One set of these traditional characteristics is the following: -

(i) there is a large and exceedingly complex body of theoretical knowledge with which are associated a number of highly specialised (and often quantitative) skills.

(ii) most students are incapable of learning more than the most elementary aspects of this knowledge and through failure or discouragement, are excluded from its study as their schooling proceeds.

(iii) even those who succeed in learning it are only preparing themselves for the real learning of the sciences that takes place in the future for a tiny minority in university and college education beyond the end of formal secondary education.

(iv) application of science learning at school is largely restricted to artificial laboratory situations or teacher demonstrations so the knowledge is divorced from real action.

(v) the content of most science curricula is discipline centred, and science disciplines are tightly defined in terms of subject matter and language.

(vi) the knowledge in science curricula is usually sequential.

(vii) the general mode of science teaching is transmission from the knowledge store of the teacher or from the text book to the learner.

At lower levels in the secondary school this set of characteristics may apply less.

One of the curriculum projects of the early 1970s at this level, the Schools Council Integrated Science Project in Britain, listed the following eleven rather more radical set of objectives.

1. (a) recalling and (b) understanding those concepts which would enable them to pursue science (courses in physics, chemistry, biology or physical science) to a higher level or as a hobby.

2. (a) recalling and (b) understanding those patterns which are of importance to the scientist.

3. making critical appraisal of available information, from whatever source, as an aid to the formulation or extraction of patterns.

4. using patterns and making critical appraisal of available information in order (a) to solve scientific problems and (b) to make reasoned judgements.

5. organising and formulating ideas in order to communicate them to others.

6. understanding the significance, including the limitations, of science in relation to technical, social and economic development.

7. being accurate in the reporting of scientific work.

8. designing and performing simple experiments, in the laboratory and elsewhere, to solve specific problems and to show perseverance in these and other learning activities.

9. be willing to work (a) individually and (b) as part of a group.

10. (a) be sceptical about suggested patterns yet (b) be willing to search for and to test for patterns.

11. be concerned for the application of scientific knowledge within the community.

This curriculum and those of several other science projects during the 1970s have been very much on the fringe of acceptance within science education but they do represent an attempt by science curriculum designers to broaden the scope and relevance of science in schools for the majority of students who will not go on to tertiary studies in science while not ignoring the minority who do.

It will be clear from what has already been said about environmental issues that, more often than not, they do involve many aspects in which scientific knowledge and skills have a part. It is therefore very obvious that science teachers have an important part to play in the overall contribution to environmental education.

Because of their backgrounds in science, science teachers will find some of the characteristics of environmental education rather novel.

The phrases Education _in_ the Environment, Education _about_ the Environment, and Education _for_ the Environment, do try to distinguish between existing sorts of education that may identify themselves with the environmental education movement.

In one sense education that falls within any of these three phrases is environmental. However, in a much more fundamental sense, an education programme that simply occurs _in_ the environment, or is only _about_ the environment is not environmental education in the sense we have defined it in this book. Science education has traditionally often occurred _in_ the appropriate environment under study, (e.g. marine biology at a sea shore, etc.) and has usually been _about_ some aspect of the natural world or environment. It has much less rarely been _for_ an immediate purpose that relates to the real world outside the classroom.

Another less cryptic way to make this point is to list in more detail characteristics for environmental education that have emerged during the international project and from the experience of the last decade.

One list of these characteristics is the following: -

1. Environmental Education is oriented to an Environmental problem or issue.

2. Environmental Education involves concern for situations that have real consequences for a society.

3. Environmental Education is interdisciplinary in its knowledge goals.

4. Environmental Education is holistic.

5. Environmental Education includes action in relation to the problem.

6. Environmental Education seeks alternative solutions/actions for Environmental situations.

7. Environmental Education is concerned with the bases for choice between alternatives.

8. Environmental Education aims to clarify values, and in some instances to change them.

9. Environmental Education seeks to develop skills for solving Environmental problems.

One of these characteristics will almost certainly require explanations. It is characteristic for environmental education to be holistic. Holistic is a term that can in one sense be understood as an antithesis of the analytic or atomistic approach that dominates most science education. In science we usually simplify real situations by isolating variables and considering as few of these together as possible. Many of our laws and principles state how one variable relates to another e.g. rate of reaction as a function of temperature, or pressure as a function of volume,etc. We also tend to see the overall situation as a simple sum of these individual components or interactions. Acceptance of the complexity of natural systems is not unknown in science, as ecologists or systems approaches testify. They are not so common in school science, but there are now good examples of these approaches through games, simulations, dynamic models, etc., that can be used in schools.

Another sense of holistic refers to the many varieties of contributions that are needed if environmental problems are to be solved. This is close to the idea of interdisciplinary in Characteristic 3, but goes further by suggesting that any disciplinary approach (even from many disciplines) is likely to have gaps, leave out aspects important to the environmental issue.

Finally, holistic refers to the fact that all sorts of modes of experience and sources of information contribute to the totality of knowledge, and should be recognised and involved in environmental education.

As we will see in Unit V, science teachers are not expected to provide all of these aspects of environmental education. The present unit sets out to remind them of the characteristics of their own subject, to familiarise them with those of environmental education and to provide some comparison between them.

<table>
<tr><td colspan="2">UNIT IV: SCIENCE TEACHING AND ENVIRONMENTAL EDUCATION</td></tr>
<tr><td><u>Objectives</u>
(1) to clarify the nature of science education
(2) to set out characteristics of environmental education
(3) to contrast these two types of education
<u>Science Process Skills</u>
communicating, analysing, comparing</td><td><u>Environmental Education Aims</u>
. to help students acquire an awareness and sensitivity to total environment
. to help students identify alternative approaches in science and environmental education
<u>Pedagogical Techniques</u>
teacher led discussion, individual and small group activity</td></tr>
<tr><td><u>Preservice Teacher Needs</u>
(1) to reinforce the knowledge students have about science teaching</td><td>
(2) to become aware of different purposes for education</td></tr>
<tr><td><u>Resources</u>
Worksheets 1 and 2.</td><td><u>Suggested Time</u>
2 hours</td></tr>
</table>

SUGGESTED APPROACH

Science teachers through their own education at school and at the tertiary level will be familiar with the characteristics of science teaching as they have experienced it at school and college.

ACTIVITY 1:

The science teacher educator, by discussion or presentation, should remind the pre-service teachers of these characteristics of their subject as taught in schools. When these have been listed and acknowledged the stated objectives of any senior secondary science course in the schools of their own country could be examined to see if any of them add further characteristics to the list. The list of characteristics of traditional science education on pages 36-37 may be a useful summary.

ACTIVITY 2:

(i) Using a recent examination paper for a senior secondary subject, the pre-service science teacher should check which of the characteristics on the list are encouraged by the examination and which are not.

A judgement on say a 3-point scale (Certainly Applies, Possibly Applies, Certainly Does not Apply) should be made for each of these objectives.

(ii) Using a recent examination paper for a low secondary science subject, the pre-service science teacher should check which of the characteristics on the list are encouraged or not encouraged by the examination.

(iii) Next, they should be asked to check the list of more radical characteristics for science education to see which of these are part of their experience of science teaching or of its examination. (Worksheet 2)

ACTIVITY 3: (Worksheet 3)

A broad topic in the local secondary science syllabus should be chosen (e.g. growth of plants, electrical energy, or production of sulphuric acid, etc.) and the pre-service teachers should be asked to suggest how this topic would be taught with the emphasis implied in the three phrases: -

Science Education in the Environment
Science Education about the Environment
Science Education for the Environment

ACTIVITY 4:

Briefly discuss the list of characteristics of Environmental Education on Worksheet 4, clarifying any terms that are not clear or familiar. Then ask the pre-service teachers in small groups to make the following comparisons: -

(i) with the definition and objective of Environmental Education in Unit III.

(ii) with the list of characteristics of science education that has been developed in Worksheet 1.

(iii) with the list of radical objectives for science education on Worksheet 2.

These comparisons should enable bridges to be recognised between the expressions of science education (examinations, experience and intended objectives) and some of the intentions of environmental education.

NOTE: It is important again to remind the pre-service teachers that they are not expected to carry all the responsibility for environmental education.

UNIT IV: SCIENCE TEACHING AND ENVIRONMENTAL EDUCATION

WORKSHEET 1.

ACTIVITY 1 and 2 (i) and (ii)

CHARACTERISTICS OR OBJECTIVES OF LOCAL SENIOR SECONDARY SCIENCE TEACHING	EMPHASIS IN SAMPLE EXAMINATION PAPER	
	Senior Sec.	Lower Sec.

WORKSHEET 2

ACTIVITY 2 (iii)

Characteristics of Integrated Science Project (U.K.)	Extent to which they apply in local science courses for 12-15 year olds.		
	Certainly Applies	Possibly Applies	Certainly Does Not Apply
1(a) recalling and (b) understanding those concepts which would enable them to pursue science (courses in physics, chemistry, biology or physical science) to a higher level or as a hobby.			
2(a) recalling and (b) understanding those patterns which are of importance to the scientist.			
3. making critical appraisal of available information, from whatever source, as an aid to the formulation or extraction of patterns.			
4. using patterns and making critical appraisal of available information in order (a) to solve scientific problems and (b) to make reasoned judgements.			
5. organising and formulating ideas in order to communicate them to others.			
6. understanding the significance, including the limitations, of science in relation to technical, social and economic development.			
7. being accurate in the reporting of scientific work.			
8. designing and performing simple experiments, in the laboratory and elsewhere, to solve specific problems and to show perseverance in these and other learning disorders.			
9. be willing to work (a) indidually and (b) as part of a group.			
10(a) sceptical about suggested patterns yet (b) be willing to search for and to test for patterns.			
11. be concerned for the application of scientific knowledge within the community.			

WORKSHEET 3

ACTIVITY 3

Consider a topic in your secondary science syllabus (e.g. growth of plants, electrical energy, or production of sulphuric acid, etc.) and briefly suggest how this could be taught with the emphases implied in the three phrases: -

1. Science Education in the Environment
2. Science Education about the Environment
3. Science Education for the Environment

Emphasis 1. ______________________________

Emphasis 2. ______________________________

Emphasis 3. ______________________________

WORKSHEET 4.

ACTIVITY 4

Characteristics of Environmental Education	Definition of E.E.	Characteristics of Traditional Science	Objectives of Integrated Science
1. Environmental Education is oriented to an Environmental Problem or issue.			
2. Environmental Education involves concern for situations that have real consequences for a society.			
3. Environmental Education is interdisciplinary in its knowledge goals.			
4. Environmental Education is holistic.			
5. Environmental Education includes action in relation to the problem.			
6. Environmental Education seeks alternatives for Environmental situations.			
7. Environmental Education is concerned with the bases for choice between alternatives.			
8. Environmental Education aims to clarify values.			
9. Environmental Education seeks to develop skills for solving Environmental problems.			

Use a tick or a cross to indicate your judgement concerning congruence with these characteristics.

CHAPTER 2

SCIENCE EDUCATION - AN ESSENTIAL CONTRIBUTION TO ENVIRONMENTAL EDUCATION

Introduction

Science is taught in schools for two main purposes. The first is to prepare that minority of students who will go on beyond school for more specialised training in science and technology. The second purpose applies more universally and it is to develop a satisfactory level of what is called scientific literacy in all students, that is, what every person should know, understand and feel about science.

But what is science? Science means different things to different people. To many it has come to mean bodies of knowledge about the natural world arranged under different subjects; to some it means research or the pursuit of truth; to some it means the development of technology intended to benefit mankind; and to others it means finding out, experimenting, measuring. Each of these is in fact a different aspect of science and a scientifically literate person is one who has some appreciation of a number of these aspects of science.

Whatever the state of development of a society, there is now a mixture of traditional knowledge about the natural world and of that which is derived from the movement we describe by the term science. The impact of the latter through modern technology, medicine and industry is increasingly influential. This makes the goal of a population literate in science both desirable and necessary. The great issues that make up the recent history of the environmental movement all involve scientific and technological aspects. This does not, however, mean that answers to the problems associated with these issues are to be found solely from within science. Nevertheless, along with other contributions, much science and technology will be involved in these solutions. Scientific literacy includes an appreciation of the strengths and limitations of science and is therefore more likely to encourage the balance of contributions from various subject areas that are required to achieve solutions to environmental problems.

One useful discription of scientific literacy makes use of seven dimensions*, each of which is now summarised.

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*Showalter, V. et al (1974) "Unified Science and Scientific Literacy", PRISM II, Vol. 2, Nos. 3 and 4, Centre for Unified Science Education, Ohio State University, Columbus, Ohio, U.S.A.

1 Interest

The scientifically literate person has developed a richer, more satisfying, and more exciting view of the universe as a result of his/her science education and continues to extend this education throughout his/her life.

This personal dimension involves a broad and persistent interest in the way the sciences expand our understanding of the natural world, and a positive but not uncritical attitude towards both scientific ideas and scientific technology. A feature of this dimension that is particularly important when considering science and environmental education is an awareness of one's part and place in an environment that is an interacting totality that includes both biophysical and social components. Because the application of scientific knowledge has often led to disturbance and damage to this environment there has been a tendency for some people to become disillusioned with science and to shy away from it or to reject it. However, the realistic recognition of how it can contribute in the totality will be in the long run a necessary contribution to the solution of environmental problems of which we are now so much more aware.

Some pointers to a person's growth in this dimension, which are useful to teachers and their students are: (i) felt and expressed interest in science; (ii) confidence to participate in science learning; (iii) preference to read, listen or watch scientific topics in the media; (iv) tendency to consider or be involved in science based hobbies or careers, and (v) perception of scientists in general with respect.

2 Practical Skills

The scientifically literate person has developed numerous manipulative skills associated with science and technology.

Because of the emphasis on scientific facts and concepts that is often found in examinations or because of unavailability of facilities and equipment, this dimension of scientific literacy has often been neglected. However, there has been a determined effort in many countries to improve the facilities for practical work, and Unesco and others* have provided many suggestions for cheap apparatus for science education. When we add to this the growing recognition of technology in science education, and of the community and the workshop as additional resources, more opportunities do exist for many students to gain some facility in practical skills. The following list may be suggestive of the wide range of equipment that can be used for this purpose - thermometers, microscope, meter stick, calculator, balance, graduated cylinder, camera, timing device, ammeter or voltmeter, etc.

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* The Unesco Handbook for Science teachers, the New Unesco Source Book for Science Teaching and Guidebook to Constructing Inexpensive Science Teaching Equipment, Science Teaching Center, University of Maryland.

3 Processes of Science

The scientifically literate person uses processes of science in solving problems, making decisions, and furthering his/her own understanding of the total environment.

One of the most significant features of science is the way scientists set about solving problems. This has become known as the scientific method, but it is not a single intellectual process nor a set sequence of processes to be slavishly followed. Rather scientists make careful use of particular combinations of these processes for the problem in hand. Many of these processes like observation and classification are not unique to science but others like the control of variables in the conduct of an experiment are peculiarly powerful in the context of the natural phenomena that are the subject matter of the sciences.

It is possible to list a number of these processes which are the ones that singly or in combination are commonly used by scientists to solve problems. These processes can be grouped as information-acquiring or information-using.

A Information-Acquiring Processes

(1) observing. The basic process of science requiring the use of all five senses to compare and describe objects and events.

(2) recognising number relations. Making use of numbers to express observations, relationships, etc. as a complement to words.

(3) measuring. The use of instruments to determine meaningful numerical values for some characteristic of objects or events such as length, volume, temperature, mass, time, etc.

(4) designing experiments. Planning a series of data-gathering operations which will provide a basis for testing an hypothesis or answering a question.

(5) controlling variables. Identifying and managing the factors that may influence an object or event (in the laboratory or in the field) so that the effect of a given factor may be learned.

(6) questioning. To raise an uncertainty, or unresolved issue about events and objects. This may be based on the perception of a discrepany between what is observed or said, and what is accepted by present scientific knowledge.

B Information-Using Processes

(1) classifying. The useful grouping of related objects or events on the basis of differences and similarities.

(2) communicating. Any one of several procedures in which information and ideas relating to scientific data are transmitted from one person to another.

(3) interpreting data. Finding a pattern or meaning in a collection of data.

(4) inferring and predicting. Explaining or suggesting what the observation of an object or event with one's previous experience will be on the basis of previous experience and existing data.

(5) hypothesising. Expressing a tentative generalisation or inference that may explain or relate characteristics of objects or events.

(6) formulating models. Constructing pictures in words, designs, material or mathematical form, that would behave, in some sense, like that of real objects and events.

Many of the environmental siutations that are of great concern today include objects and events that lie within the fields of study of natural scientists. Accordingly, as part of the solving of these environmental problems it is important that as many of these powerful tools of science be brought to bear as possible. An appreciation of these and their use is thus very much a contribution science teachers can make to the scientific literacy of an environmentally equipped population.

4 Concepts in Science

The scientifically literate person knows and accurately applies a number of science concepts, principles, laws and theories in interacting with his total environment.

Over the years scientists have developed or invented a number of concepts that are terms which express regularities in objects and events. Likewise the principles or laws of science are statements of relationships between concepts. They can take quantitative or qualitative forms. For example, force and acceleration are linked quantitatively by the formula, Force = Mass x Acceleration, while the Periodic Table portrays the electronic structure of the atoms of the elements in a quantitative way but indicates only qualitative trends in their chemical properties.

As the amount of knowledge generated by scientific research has increased enormously, the emphasis of science teaching has changed from the simple recall of many items of information, to an understanding of a number of these concepts, principles and laws that summarise or represent these aspects or phenomena.

Some concepts (see examples below) relate to many branches of scientific knowledge. Other concepts are restricted to specific fields of knowledge and have precise and specialised meanings in those contexts. The scientific meanings for words like work, animal, mixture, force, volume, etc. need to be recognised as being very useful to scientists in this form. They may be used in other less precise ways quite usefully by other persons in other contexts or in everyday life.

Some concepts that have wide applicability in the sciences are the following:

1. *change.* When an object or situation is in the process of becoming different or something else.

2. *cycle.* The apparent pattern in which certain events or conditions seem to be repeated at regular intervals or periods.

3. *equilibrium.* That state of affairs in which changes or tendencies to change in opposite directions, exist in balance or are happening at equal rates so that a stable state is evident.

4. *field.* A region or space in which something influences or affects something else, often without direct physical contact.

5. *interaction.* A situation in which two or more things influence or affect each other.

6. *invariance.* A characteristic of an object or a situation which stays constant even though other characteristics may change.

7. *perception.* The interaction between the human mind and the external world.

8. *probability.* The relative certainty (or lack of it) that can be assigned to certain events happening in a specified time interval.

9. *significance.* The belief that certain differences which exist or which follow certain actions exceed those that would be expected to be caused by chance alone.

10. *population.* A group of fundamental entities that have certain similarities or common characteristics.

11. *system.* A group of things or events which can be defined, at least in part, by boundaries that one person can communicate to another and which enable it to be discussed and studied more effectively.

12. *resonance.* An action within one system which causes a similar action within another system.

13. *symmetry.* Patterns in nature that are structurally or functionally independent of direction.

A number of broad concepts are of particular use in considering the events and objects of environmental situations. Among these are Energy, Ecosystem, Resources, these are discussed and developed in some detail in Appendix 1.

5 Nature of Scientific Knowledge

The scientifically literate person understands the nature of scientific knowledge.

There has been a tendency in school science education to emphasise only some aspects of scientific knowledge. Traditionally, science courses were prone to be an encyclopaedic collection of facts about objects and phenomena. More recently some new science curricula have strongly emphasised the methodology of processes of science (see Dimension 3) while others have been more theoretical or conceptual (Dimension 4). In both these types of curricula, there has been a tendency to lose sight of the actual events or objects in nature that are being described or studied.

A useful diagram that incorporates and relates these three aspects is Gowin's V* .

This is shown in Figure 2.1.

At the bottom of the V and integral to its two sides are the events (natural phenomena) or objects that are the ultimate subject matter of science.

On the right hand side are all the intellectual skills (or processes) and the experimental procedures that make up the methodology of the scientist. On the left hand side are the concepts, principles and theories that scientists have invented and that have proved useful in describing and explaining these events and objects. Linking the two sides are the questions or problems that relate to these events and objects. Answering these questions or solving these problems involves the use of both sides of the V. Sometimes when scientists can use the methods on the right to check a claim or idea about their objects or events they establish new concepts and new theories and thus build up the left hand side. Older views of this side of the V may in this way be modified or displaced.

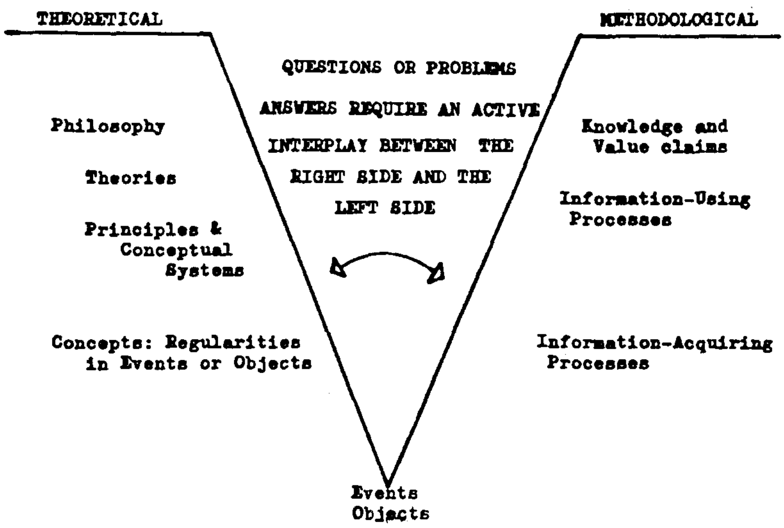

Fig. 2.1 Gowin's V: A diagrammatic portrayal of the way scientific knowledge develops

* The heuristic device devised by Robert Gowin of Cornell University has been described by several papers by his colleague Professor J. Novak, e.g. in "The Reception Learning Paradigm", J. Research Science Teaching, 16, No. 6, 481-488 (1979).

This picture of the nature of scientific knowledge enables us to see its dynamic and potentially evolving character. It also helps us to see that answering questions or problem solving - the pre-eminent features of environmental education - also lie at the heart of scientific knowledge.

A number of words have been used to describe the nature of scientific knowledge. It is called *empirical* to emphasise that it is based ultimately on observation or experiment, that is, the real world of sense experiences. It is said to be *universal* or *replicable* because this empirical evidence is not dependent (at least in theory) on the persons (or their location) who generate it. It is called *public* because its evidence if accepted would lead other individuals to the same conclusions. It is *tentative* in that its concepts and theories that are useful to explain events are socially constructed or invented and thus are subject to change. At any time its present worth is based on its usefulness and this is not diminished by this possibility of ultimate impermanence, since the new concept and theories will lead to greater use.

6 Values

The scientifically literate person interacts with the biophysical aspects of his/her environment in a way that is consistent with the values that underlie science.

Among the values that have assisted the development of scientific knowledge, we can list the following:

1 longing to know and to understand

2 questioning about nature and ideas that describe or explain nature

3 searching for data and their meaning

4 demand for verification

5 respect for logic

Without these persistent values in some people we would not have the impressive body of knowledge that exists as science today. Nor would we have many of the applications of this knowledge that have transformed in positive ways the nature of social life in most countries.

The conscious recognition of these values has not occurred as commonly or as explicitly in school science education as their fundamental importance warrants.

To develop this dimension, learning experiences need to be included in science education in which these scientific values are identified and contrasted with other sorts of values such as aesthetic, economic, or social ones.

For example, it has been suggested that some of the values underlying the scientific enterprise are in fact aesthetic ones, and that others are strongly influenced by recognition that scientists give each in the international community of science. On the other hand the values like 4 and 5 above are often seen as particularly important in science and as less significant in other fields. Environmental issues such as the degree to which a factory effluent is to be purified or the optimal location of an airport, are excellent subjects to establish such learning experience. These sorts of subjects include very obvious scientific aspects and scientific values are relevant to the problems associated with them. Other sorts of values will be associated with the other aspects of the situations. In considering how decisions about these issues are made, the contrast of values will be clear. A number of science curriculum projects have developed kits (games, case studies or simulated projects) that can assist teachers in this type of science learning.

Sometimes scientific knowledge is presented in ways that become very dominant in any assessment of complex environmental situations. In developing this knowledge scientists often regard the natural world as an 'object' of study, rather than ecological as an interactive system that includes themselves. The outcome is a mechanistic world view that in some senses can reinforce attitudes and behaviour that have been very destructive of environment.

Now, more freely than a few decades ago, it is commonly recognised that science itself can be influenced by other sorts of values that take the form of bias. Scientists have shown in a number of fields a tenacity to reject certain scientific work because of its clash with existing perspectives, theories or practices. Any historical look at one of the sciences can produce many examples, and in fifty years time it will no doubt be clear that similar biases are operating at present.

Then there is the bias based on differing social or political values that enables some scientists today to take different stances on the data concerning cigarette making and lung cancer, or on the disposal of radio-active waste. In these cases, it is important for the scientist to be aware of the bias of his/her position and to report it concurrently with any conclusions. As science makes its contribution to environmental problems this reporting of bias will be increasingly important.

7 Science-Society *

The scientifically literate person understands and appreciates the joint enterprise of science and technology and the inter-relations of these with each other and with other aspects of society.

The distinctions and the relations between science and technology are useful to discuss because there is often confusion about them.

Research scientists and many science educators have tended to see science and technology as separate. Indeed these sorts of persons often tend to see science as a precursor to technology and as essentially value-free. Technology results from a subsequent application

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* Much of this section and Unit VIII with grateful thanks is drawn from Science and Society - a booklet that forms part of Man and the Physical World, ed. G. Wright, V.I.S.E. St Kilda Road, Melbourne, Victoria 3004.

of scientific knowledge and only then, these persons argue, it is proper to ask moral or social questions about the effect or consequence of this application. There are, of course, a number of examples today of just this sort of sequence from scientific knowledge to a new piece of technology.

Historically, however, a great deal of technology has developed by the practical improvement of traditional crafts or, pragmatically in the face of new social demands. The science of this technology may by now be more or less understood, but it certainly was not the springboard for it. Science in these cases provides a rationalisation of established practices but did not generate them.

There are also a number of examples where these sequences are extended. Existing technology may need to be improved or replaced and this practical demand opens up major new scientific enquiries the outworking of which goes far beyond the original problem. As a result the technology is improved and sometimes quite new ones emerge as well.

Technological change has been an inseparable part of the history of mankind and continues to be one of the dominant features of our lives in this century. From the time of making and using stone tools right up to the present age of electronic computers, there has been a continuing progression of new inventions, new tools and new ways of doing things. The ages of human history are often described in terms of the dominant materials and technology used - stone age, bronze age, etc. - indicating the importance of technology to the development of civilization.

The changes in technology of the past have not been the only factors in the growth of civilization - language, arts, philosophy, religion, economical and social organisation have always been other types of expression of the way societies have perceived themselves and behaved. Yet there are many points in history where a dramatic turn was made which could be attributed to the invention of a single new process in technology. Some examples of this are the discoveries of fire, the wheel, paper and the printing press; all of which had very wide reaching social effects.

Up until about 200 years ago, technological progress took place at a relatively leisurely pace. The maintenance of a tradition of the ways things were done and the kinds of materials used was generally more important than any drive to change these traditions.

Since the industrial revolution however, technological change has become one of the prime interests of large segments of our society. Activity in science is measured in terms of the rate of discovery of new, important ideas. These ideas are rapidly made use of by engineers, and whole new industries and new products or processes come into being. The present urge in many places is not to maintain traditional methods but to change. Technological change is as much a part of our lives now as was people's dependence on tradition and non-change in earlier times.

The physical environment of all city dwellers is almost totally man-made. It is heavily influenced by technology, often science based and usually involves some scientific knowledge. This invasion by science into our environment is increasingly true also for persons who live in the countryside. It is quite difficult to find objects in our environment which have not been the subject of scientific study. And knowledge about an object invariably provides mankind with the potential to affect it.

Even natural substances like a piece of wood have often been through the science mill. Botanists have peered at it through a microscope. Foresters and agriculturists have cultivated, fertilised and harvested it. Other experts have milled it, treated it against disease and dried it under controlled conditions. Furthermore, all knowledge on which the production of the piece of wood rests, is to be found in books. It is highly specialised knowledge, and is handed on in a formal way by a science education system. The fund of knowledge and practice relating to wood is constantly growing, not by the contributions of people working with wood every day, but by the contribution of specialists whose sole job is to find out more about it. Much of the new knowledge is produced from laboratory controlled experiments.

A piece of wood bought from a local store may be as much a product of modern science and technology as an electronic calculator.

To the ordinary person the distinctions between science and technology are much more blurred. They are likely to give a digital watch, or transistor radio or a satellite as an example of science when scientists may wish to see these as examples of technology. However to the mass of these citizens, the application of scientific knowledge in their lives, and its ability to change how they do things, or how things are done to them, represent the real meaning and value of science. By the same token many of the critics of science have based their case on technological applications which have had undesirable side effects of such a magnitude that they outweigh the original desirable ones. As long as such large proportions of scientifically trained professionals are employed in the industries of weapons technology, the association of science and potentially negative affects is obvious and inevitable.

An understanding of the links between science, technology and society cannot be gained by simply studying and/or memorising details of these relations. Understanding and appreciation will be developed when an assortment of specific situations involving these components are studied in active fashion.

Environmental situations can be ideal for such study. Often they are directly relatable to the impact of technological change. Even more commonly they have scientific aspects that require some sort of technological intervention to be made if any resolution is to be achieved. Accordingly, any science teacher wishing to develop this dimension of science/technology at all will find himself/herself engaged in environmental education.

There are many cross-links between this dimension of scientific literacy and others. For example, some scientific knowledge may not be seen to engender strong attitudes or value judgements, but its direct outworking as technology may readily do so. These consequences may be directly related to the social application of scientific knowledge, or to the social process whereby the application is determined.

Again, because of their basic personal value positions or because of the tentative nature of existing scientific knowledge, scientists/ technologists may differ among themselves regarding the same application of science.

Many of these dimensions of scientific literacy will be familiar to science teacher educators. A number of them and their associated pedagogical methods will be covered in the usual training programmes of most science teachers.

From the above discussion, it will be clear that many of them are quite integral to any science teaching that sets out to contribute to environmental education. Thus, many of the units of this book include activities and pedagogical training that will assist science teachers in achieving scientific literacy in their students.

The remainder of this chapter contains four units. The first provides a useful way of looking at the relationship between science education and environmental education.

The next two units are exemplary ones of how teaching from the learning of science process skills (Dimension 3 above) can be done within the sorts of context the environmental situations so readily provide to science teachers. A problem with some of the science curricula that emphasise these process skills is that they under-rated the role of science content. The science content is important to the learner and the best learning of process skills is likely to occur when very meaningful and important science topics are being studied. Environmental situations can easily be found that contain this sort of science content.

The fourth unit is concerned with the Science-Society dimensions (No. 7 above) because it is still less commonly emphasised in science teacher training than are most of the other dimensions of scientific literacy.

The next two units explicitly emphasise the need to teach for some of the processes of science (Dimension 3 above) using the sorts of context that environmental science teaching so readily provides. The fourth looks at Dimension 7 - the Science-Society one - because it is still much less commonly found in science teacher training than most of the others.

UNIT V

ENVIRONMENTAL EDUCATION AS PART OF SCIENCE EDUCATION

INTRODUCTION

Environmental education as we have defined it in this book so far clearly goes beyond the boundaries or capacity of the teacher of a single subject. How then can it be part of secondary education and of science education is particular?

Perhaps it should be a new subject for the curriculum with its own subject matter, its own methods of enquiry, and its own super teachers? For all sorts of reasons we reject this proposal. There is firstly, the very practical one that secondary curricula in most countries are already over-crowded and any new subject would have low status and have to fight to displace another subject of established value. Secondly, as we define it, it is not a discipline with its own subject matter distinct from existing subjects. Accordingly, it is unrealistic to think of the super teacher who could encompass in themselves all aspects of environmental education. Finally, to make it a separate subject is to lose sight of the fact that environmental education is a philosophy which challenges existing education as a whole to contribute to the resolution of the crisis facing humankind in its environment.

In rejecting the separate subject approach in favour of one that expects teachers in all subjects of the secondary curriculum to contribute to environmental education we are conscious of two shortcomings. They both arise from the almost universal organisation of secondary schooling into a number of discrete subjects of study. This pattern means that the students have overt models in their own teachers of the learning they are expected to undertake. The teacher usually is 'expert' in only one or two subjects and yet the student is to acquire knowledge in a large number. Secondly, this compartmentalisation of knowledge into disciplinary subjects means that many aspects of life and important questions are not dealt with by any subject teacher in the curriculum.

Both of the features of secondary schooling are again very relevant to any discussion of environmental education and they do mean that the approach described below has definite limitations. Once again the students are expected to achieve an integration of knowledge and learning for the environment that is not required of their teachers. Secondly, even when well applied the approach will leave out a number of aspects of any environmental situation because it does have a holistic (or integrated) character that goes beyond a good interdisciplinary view. Nevertheless since secondary schooling operates with this fragmented knowledge pattern we have set out to find an approach that will optimise its contribution to environmental learning.

How then can the existing parts of secondary education and science in particular contribute to environmental education? In answering this question it is important that science teachers are not overwhelmed by what is expected or lose sight of the other important contributions they have to make to the schooling of their students.

The set of characteristics for environmental education that were given in Unit IV can be used to identify when, and in what ways, science education, as part of the secondary curriculum, can contribute to environmental education.

The task, using these characteristics, is to delineate the contribution of science education to an overall curriculum emphasis on the environment. At the same time proper appreciation of this task should liberate science teachers (and teachers of other subjects) from any sense that perhaps all their science classes are supposed to have this environmental character.

Science (like other subjects) has a number of contributions in its own right to make to schooling and our process here should also clarify and support these. Figure 2.2 illustrates a suggested approach in which science education contributes to environmental education but is only a part of the totality. Furthermore, it is clear that science education is only part of its time concerned with environmental matters.

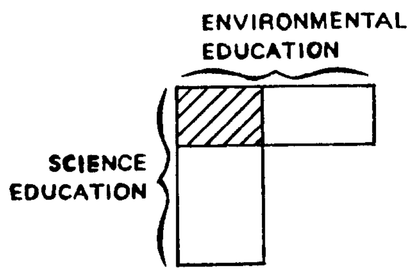

Figure 2.2 An overlap model for the way science education contributes to environmental education.

Figure 2.3 shows the outcome of this procedure when it is extended across all the subjects of the curriculum. The hatched setments for each subject in these two Figures together contribute to environmental education.

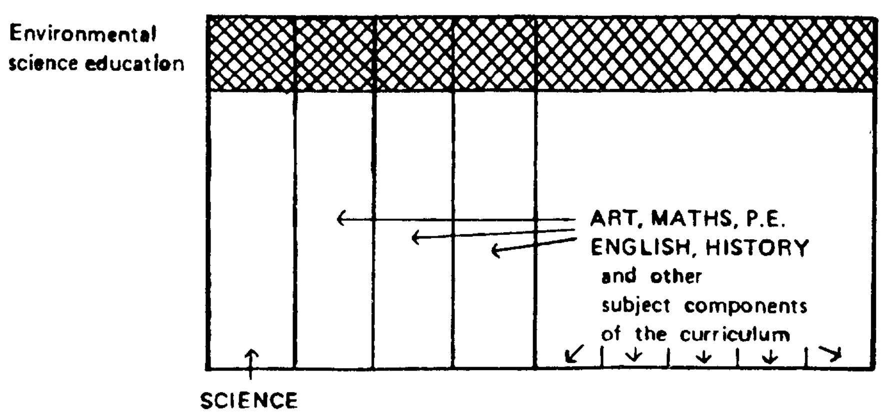

Figure 2.3 The overlap model showing how all the subjects of the curriculum can contribute to environmental education.

The areas of non-overlap represent curriculum content in these subjects that exist for other valid educational reasons. For example, a biology course of study may have a strong ecological emphasis (and hence be education <u>about</u> the environment) without having the more distinctive characteristics 1,2,5,6 and 9 (see page 37) of environmental education. Such curricula are nonetheless good biological education when they serve other valid functions of schooling. In this way we also avoid the confusion that has sometimes arisen that environmental education is just 'good' biology or 'good' geography and vice versa.

How in the case of science education can we spell out how this overlap model might work? This unit gives the science teachers the opportunity to practise its use.

UNIT V: ENVIRONMENTAL EDUCATION AS PART OF SCIENCE EDUCATION	
<u>Objectives</u> (1) to assist students to see how science teaching contributes to environmental education (2) to enable students to recognise that other subjects also contribute to environmental education	<u>Environmental Education Aims</u> . to help students acquire an awareness of and sensitivity to the total environment . to help students develop a basic understanding of the total environment . to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems
<u>Science Process Skills</u> communicating	<u>Pedagogical Techniques</u> (i) teacher directed (ii) small group discussion
<u>Preservice Teacher Needs</u> (1) to feel confident that as science teachers that have knowledge and skills to contribute to environmental education (2) to feel re-assured that science teachers do not carry whole responsibility for environmental education	(3) to know that only part of their teaching should be directed to an environmental emphasis
<u>Resources</u> Worksheet	<u>Suggested Time</u> 2 hours

SUGGESTED APPROACH

<u>Step 1</u>

Divide the class into five small groups and provide each group with a Worksheet that shows the two overlap diagrams. Give one group the broad topic Ecosystems, another Energy, another Population, another Food and another Resources.

Explain the digaram in Figure 2.2 to them making sure they understand that the whole vertical column represents topics, concepts, principles, experimental skills, etc. that are suitable ones for science teachers to teach (e.g. the syllabus content (or part of it) of the same level of a science subject in your country).

Then explain the distinction between the hatched and unhatched areas of the column. The hatched area represents those science content aspects of a syllabus topic (or a whole syllabus) that, as well as being science, also have the characteristics listed on the Worksheet (see also Unit IV) that help us to define environmental education. Science content that does not have these characterisitics (or the obvious potential to be taught in that way) belong in the unhatched area of the diagram.

Step 2

Each group is then to make two lists of content (concepts, principles, experimental skills, etc.) that would be appropriate for a science teacher to teach under the broad topic the group has been given. In the list that is to be related to the hatched area, the content details must at least need characteristics 1 and 2 from the list. Characteristic 3 can be met by trying to think of the way the sciences infringe on problems within this broad topic. In elaborating detail to the content list the teachers should be encouraged to include characteristics 5 and 9 and also some attempt at 6 should be made.

Step 3

After some time concentrating on the content relatable to the hatched area, the teacher should be encouraged to make the other list of the science content under their topic that does not and need not have these characteristics. Much of the science content of most syllabuses will be in this unhatched area and its importance for teaching is obvious because it meets other objectives and because it is the basis of whatever examination or testing system exists.

Step 4

When both these lists have a number of examples of appropriate content, the **students** should be asked to consider characteristics 4, 7 and 8. In their groups they should be asked to discuss whether as science teachers, they might be able to contribute to them when teaching the content related to the hatched area (i.e. their first list) or whether they should be better left to other teachers as the diagram in Figure 2.3 suggests is appropriate.

Step 5

Finally the group should be encouraged to list aspects of their broad topic that would be very appropriate for other subject teachers to teach within the hatched part of their subject columns in Figure 2.3.

Note The science teacher educator may prefer to illustrate the process by taking the class through the steps with an example. The topic, ENERGY, is an easy one because it has obvious aspects like the use of energy for heating and working that relate to the hatched area and others like conservation of energy that relate to the unhatched area. It also has obvious aspects like fuel sources that can be treated historically and geographically, etc.

UNIT V

ENVIRONMENTAL EDUCATION AS PART OF SCIENCE EDUCATION

WORKSHEET

INTRODUCTION

Science teaching in schools has many objectives. The many topics in a science course introduce students to a number of concepts, principles, processes and experimental skills that are useful to them and important for them as they proceed through schooling.

Among these aspects of the content of many broad science topics, there are a number that provide science teachers with excellent opportunities to make a contribution to the environmental education of their students.

In this unit you will be introduced to a process that enables you to identify those opportunities. It will also encourage you to see your science teaching as contributing to a number of needs of your students - one of which is environmental education. Finally it should become clear that not all the responsibility rests on your shoulders. The teachers of the other subjects in the school curriculum also have their share to make to this important goal.

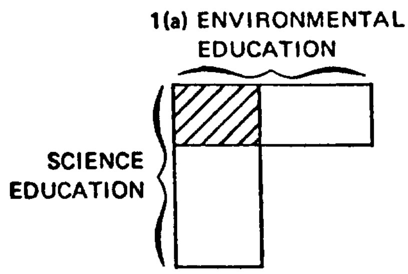

Figure 2.2 An overlap model for the way science education contributes to environmental education.

Broad Topic: ____________

In List 1 below, write details of science content (concepts, principles, experimental skills, etc.) that can be related to the hatched area of Figure 2.2. To be in this list they should have to be suitable for the Characteristics 1 and 2 listed on this sheet. You should be able to relate some to Characteristic 3 and with some effort the detail of some content can be made to meet Characteristics 5, 9 and perhaps 6.

In List 2 below write the content details that belong in science courses to your broad topic but which do not (and need not) have the Characteristics of environmental education.

WORKSHEET 1 (Contd.)

List 1 (Environmental Education)	List 2 (non-Environmental Education)

Characteristics of Environmental Education

1. Environmental Education is oriented to an Environmental problem or issue.

2. Environmental Education involves concern for situations that have real consequences for a society.

3. Environmental Education is interdisciplinary in its knowledge goals.

4. Environmental Education is holistic.

5. Environmental Education includes action in relation to the problem.

6. Environmental Education seeks alternative solutions/actions for Environmental situations.

7. Environmental Education is concerned with the bases for choice between alternatives.

8. Environmental Education aims to clarify values.

9. Environmental Education seeks to develop skills for solving Environmental problems.

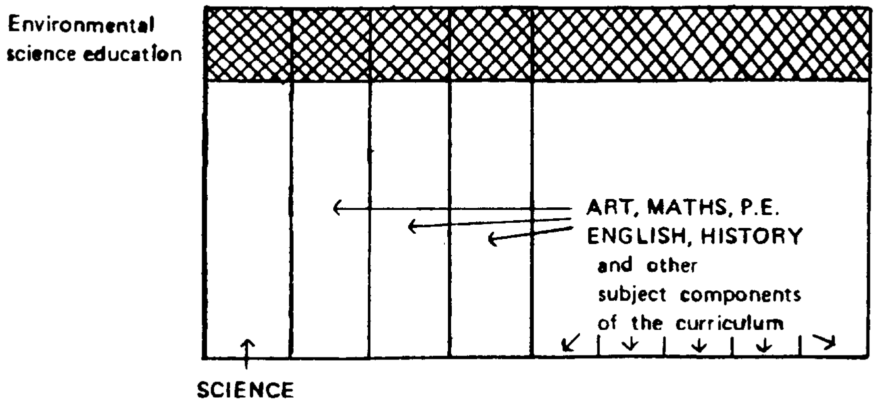

Figure 2.3. The overlap model showing how all the subjects of the curriculum can contribute to environmental education.

In List 3, suggest some aspects of your broad topic that could appropriately be taught by other subject teachers. These contributions to a student's overall environmental education would relate to the hatched areas at the tops of the other columns in Figure 2.3.

List 3	
Topic Aspect	Subject Teacher

UNIT VI

OBSERVING AND CLASSIFYING - BASIC SKILLS IN SCIENCE AND ENVIRONMENTAL EDUCATION

INTRODUCTION

The basis of all scientific knowledge is observation. This entails recording not only the purely visual aspects of an object, but also all the information that can be obtained directly through our senses, or the extension of these senses through tools and instruments of many sorts.

The recognition and observation of a wide range of characteristics associated with any particular object leads, via careful recording and measureemnt to well defined properties. Any one of these will exhibit a range of values when a number of objects are considered. The selection and arrangement of classifying systems from such a range of property values can range from those designed purely to distinguish between objects that look superficially much alike (e.g. classification keys for identifying plants) to a system that categorises objects according to their usefulness for a particular purpose (e.g. trams, trains and planes could be grouped as forms of mass transport while bicycles, small cars and small boats are not)*.

All such classificatory systems are therefore artibrary and their value depends entirely on the purpose for which the classification is being undertaken. Scientists find it useful to classify many very different animals together in the Class Mammalia but a farmer would not find such generality very useful.

The starting point of this unit is the occurrence of the multiplicity of objects that litter an area. In many societies the constant and accumulating nature of litter production is now a problem. Until the scarcity of resources and of energy became so apparent, the major problems were disposal and hygiene. Now, however, a number of methods of disposal (e.g. burning) which were hygienic in one sense are now seen to be polluting in the long term. They are also energy-consuming and wasteful of scarce resources. Increasingly, there is an interest in recycling certain components of the world's litter. An energy-poor or energy-concerned country might wish to conserve energy resources by reducing the energy wasted in litter. To do this, it is necessary to establish to what extent litter contains articles that have been produced as a result of high energy input. The development of a classificatory scheme applied to a heap of rubbish might therefore look something like Figure 2.4.

Such a classificatory scheme sorts out basic and relevant information but does not by itself resolve the underlying issue. In this example, the amount of energy that would be saved in reducing litter by extracting these items for recycling depends on a number of factors. The two most important are: the amount of energy actually expended in collecting the litter; and the amount of energy required to sort it out. Other significant factors could be the amount of

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If the issue was a science resource like copper or lead what might the classification scheme look like?

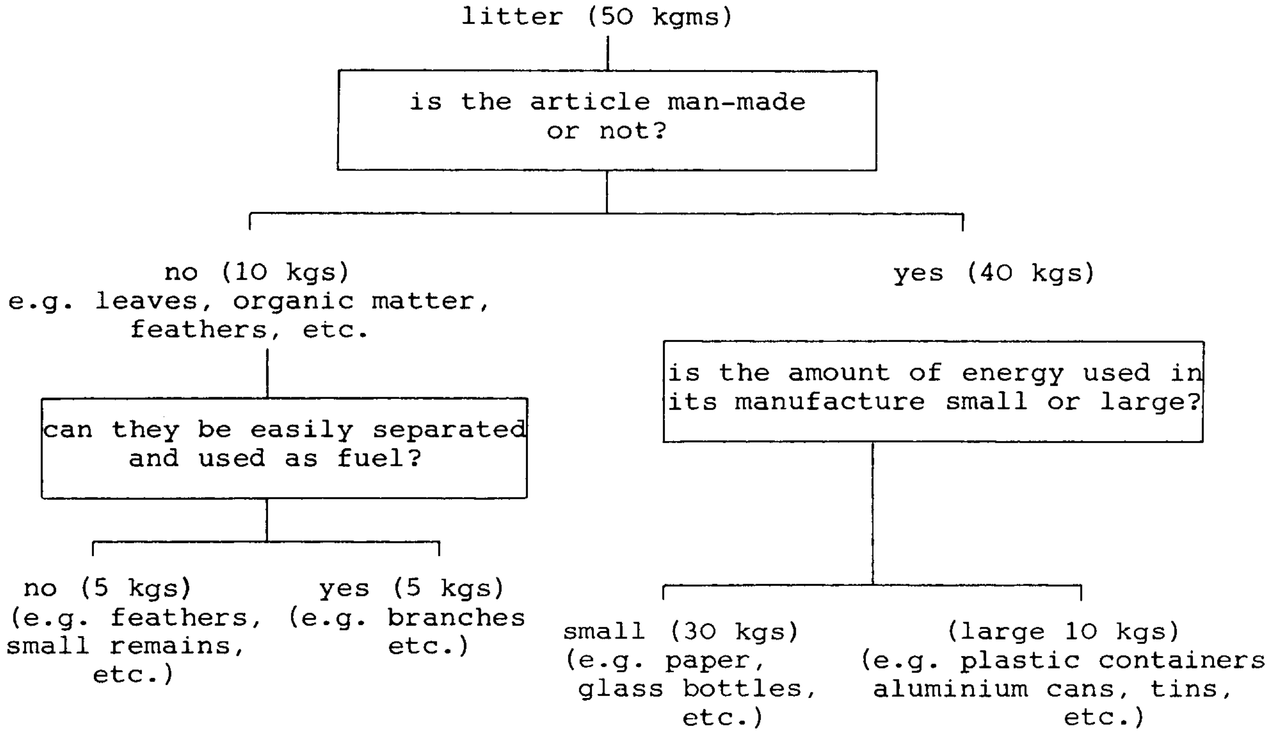


Figure 2.4. A classificatory scheme for litter.

energy required to reprocess the manufactured litter into some useful objects and the amount of energy that could be obtained from litter that is easily used as a fuel.

Decision-making concerning changes in litter practices will depend on these additional analyses and data. There would, however, be no basis for this further analysis if the observations and classifications were not carefully done.

This unit will provide the teacher with practice in the process skills of observation and classifying and will help them to see how an environmental situation can be used to teach science content and these science processes.

UNIT VI: OBSERVING AND CLASSIFYING - BASIC SKILLS IN SCIENCE AND ENVIRONMENTAL EDUCATION	
Objectives (1) To assist students in the making of observations (2) To develop students' ability to communicate clearly and accurately (3) To develop in students the realisation that the property selected as a basis for classification is of an arbitrary nature related to the purpose of the classification (4) To promote in students the realisation that a range of classification schemes is possible	**Environmental Education Aims** . to help students acquire an awareness of and sensitivity to the total environment . to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems to help students acquire the motivation for actively participating in environmental improvement and protection
Science Process Skills observing, communicating, classifying	**Pedagogical Techniques** teacher direct discussion
Preservice Teacher Needs (1) To feel that they have developed a better understanding of the nature of science	
Resources access to a range of litter (or rubbish)	**Suggested Time** 1 hour minimum - up to 2 hours, depending on the activities selected from the unit.

SUGGESTED APPROACH

Step 1

A: student-centered

Pre-service teachers are taken into the schoolyard (or walk along a 400 metre stretch of road, footpath or creek) and asked to collect all the litter that is to be found there.

B: teacher-centered

The science teacher educator provides the class with a rubbish bin containing unwanted refuse.

Step 2

The pre-service teachers are then asked to write a description of one or more of the articles classed as litter or rubbish. Such a description should contain reference not only to the visual attributes of the article but also to one or more of the following properties: natural or man-made, weight, volume, level of energy required in its manufacture, biodegradability, the nature of the resource from which it was made - renewable or non-renewable, etc.

Step 3

Each person is then asked to read out their description of the article(s) and the rest of the group comments on the clarity and accuracy of the statements.

Step 4

There are a number of issues that involve litter. These include aesthetic aspects, energy wastage, non-renewable resources, and economic possibilities of it as a raw material. For one or two of these issues, the pre-service teachers are asked to check their descriptions to see if they referred to any observable properties that could be used to sort litter in relation to these issues. If not, discuss what property is relevant and how it could optimally be observed.

Step 5

Using this property a classificatory scheme of the type shown in Figure 2.4 should be devised and diagrammatically presented. Students should be encouraged to critically assess the potential use of each other's schemes in various litter situations.

UNIT VII

SUGGESTING HYPOTHESES AND DESIGNING EXPERIMENTS

INTRODUCTION

Both scientific knowledge and much of its application proceeds and develops by the postulating and testing of hypotheses. Put simply, these are tentative generalisations that can be used to explain a number of observations. Such generalisations in science are testable by making further observations under controlled conditions. This overall procedure for the testing of hypotheses is what, in strict use, the term, experiment, belongs to. Conversely, a generalisation or statement cannot be a scientific hypothesis unless it can be tested. In this strict sense, the primary purpose of scientific experments is to test hypotheses. In science education, and in science practice, the term, experiment, is also used to cover many other sorts of practical activity.

Let us consider an example. Algae are found in most aquatic ecosystems, although their abundance and type seems to depend on a large number of factors. It is observed that as the water in a river or lake becomes more polluted the quantity of algae increases.

Here we have an observed phenomenon which arouses curiosity. What causes the algae to become abundant? An hypothesis is needed to explain the phenomenon, and it must be based on our knowledge of algae and of water pollution. Perhaps the algae become more abundant because the pollution makes the water more murky and darker, allowing the algae to grow more quickly. Or, perhaps there is something in the pollution, for example more nitrates, which stimulates algal growth.

Both of these hypotheses can be expressed in such a way as to be testable. For example:

Hypothesis: *If algal growth occurs more quickly in the dark ...*

Prediction: *then keeping a sample in continuous daylight should inhibit growth.*

This can be tested, as can the other possibility:

Hypothesis: *If algal growth occurs more quickly in the presence of nitrate from the pollutant,*

Prediction: *then adding nitrate to a sample would increase growth.*

Experiments test hypotheses by checking the correctness of the predictions that can be derived from them. However, a prediction can be observed to occur although in fact its hypothesis was false. This is because some unnoticed accompanying factor is also present and it is the significant one. Valid predictions rarely (if ever) constitute a full proof of the truth of an hypothesis. Further exploration of other possible conditions would be necessary before the hypothesis could be affirmed. Experimentation more easily negates hypotheses than supports them.

Thus, experimental design, in which all likely variables are considered, is an important aspect of the work of scientists.

In this unit, a situation involving the death of fish is taken, and pre-service teachers are asked to postulate possible causes, construct testable hypotheses for each of the causes, and then develop a possible experimental design that could test one or more of them.

UNIT VII: SUGGESTING HYPOTHESES AND DESIGNING EXPERIMENTS	
Objectives (1) to develop students ability to construct hypotheses (2) to assist students in designing experiments that test a given hypothesis	Environmental Education Aims . to help students develop a basic understanding of the total environment and the inter-relationships of man and the environment. . to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems . to help students acquire the motivation for actively participating in environmental improvement and protection
Science Process Skills hypothesising, designing experiments	Pedagogical Techniques brainstorming, teacher directed discussion, role playing
Preservice Teacher Needs (1) to feel that they have developed a better understanding of the nature of science	
Resources a relevant news item, textbooks relating to topic being investigated (optional)	Suggested Time 1 hour minimum or 2 one-hour sessions, if the nautre of an 'hypothesis' has to be taught as an introduction to this module

SUGGESTED APPROACH

Step 1

The science teacher educator reads to the group a real or fictitious 'news item' similar to the following:

> 'Yesterday it was reported that great numbers of dead and dying fish were seen floating in the local river (the river .....). People are warned

> against eating these fish because it is believed that they may have been poisoned following a possible discharge of contaminated waste from the newly opened paper-making plant upstream in the town of .....'

Step 2

Pre-service teachers are asked to brainstorm and suggest as many reasons or causes as possible to explain the fish-kill.

Step 3

For each cause the class as a group, or individually, should produce a statement of the sort:

> 'If .... then ....'

Step 4

Each statement produced is to be discussed by the class, with particular emphasis on the testability of the statement, that is, the extent to which the suggested cause comes within the scope of science.

Step 5

Following such discussion each pre-service teacher is asked to imagine that they are employed by the responsible authority to investigate one of the causes. Their task is to devise (using tests, or advice from relevant experts, etc.) the manner in which the experimental investigation could be carried out. (At this stage the constraints of availability of equipment or expert persons are not to be considered.)

These can be checked by the science teacher educator and several of them presented and discussed at a later time to see if all agree that they would in fact test the original statement.

UNIT VIII

SCIENCE, SOCIETY AND TECHNOLOGY

Most human beings spend their time day by day in a number of different environments. Some of them are very personal such as home or a place of work. They may be shared by a few people or in the case of a large company or institution many people may work together in the same physical surroundings. Most persons at some stage spend a significant period in an environment that is devoted to education or school or college or university. Then there are the wider environments in which these persons live, work and play as members of a society. These may be small rural communities, island societies or large cities.

Each of these environments is likely to have seen changes over the last fifty years and most school children in the world today are familiar with things that were not available when their parents were at school. These new objects and changing ways of living, working and playing are, in many instances, associated with what is broadly described as technology.

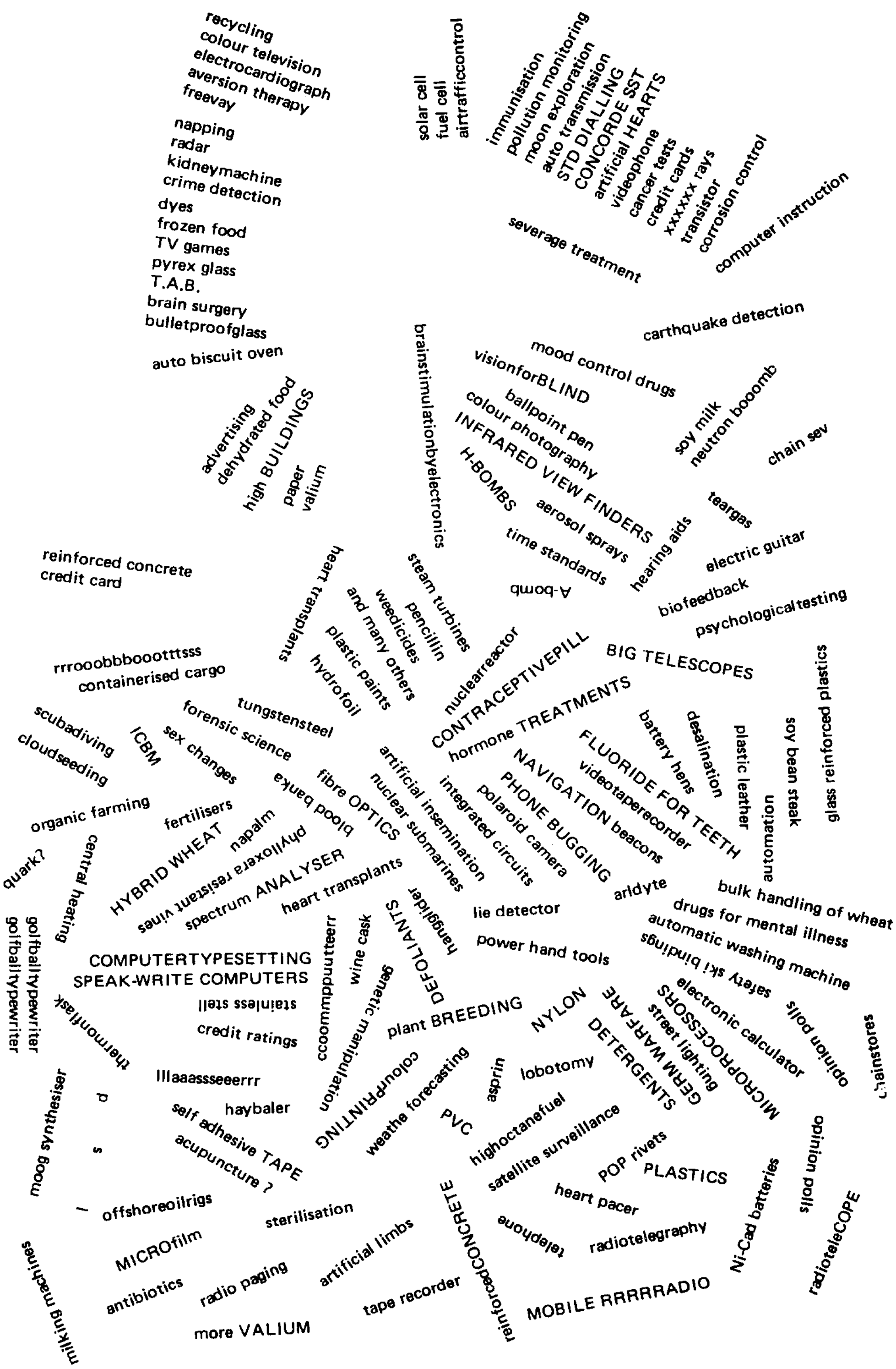
Each of these examples of technology depends on a history that has involved scientists, technologists and ordinary people. For each, there has been a group of people who have been seeking new ways of doing things and in some cases new things to do. They have provided an impetus for change. Although some of these have resulted, as most technology did prior to the 19th century, from the persistence and ingenuity of persons with little or no formal education in science, many of them have acquired the specialised knowledge and skills of those persons we now know as scientists and technologists.

Part A The Technological Society and its Related Science

In Figure 2.5, there is a collage of inventions and technologies that exist in modern society. The vast majority of these were not in existence 100 years ago. Even those that were, like paper or wood (see discussion on page 54) are now treated and prepared in rather different ways that are the result of the new knowledge and skills of the specialists. This 20th century has been the Century of Science. The number of people involved as scientists and technologists has increased many-fold and the effort now expended in scientific research is in orders of magnitude higher than it was 100 years ago. Scientific knowledge and new technologies have in turn accelerated.

Petrochemical industries are an example of scientific technology that pervades almost everybody's life in some way. In their modern form, the contributions of scientists can be found at almost every stage from the finding of the oil in the ground to the production of the finished products. Basic to the discovery of deposits is an understanding of the geology of oil traps and the techniques of exploration, such as shock wave recordings. Engineers design and develop drilling techniques which have evolved as a result of both practical experience and laboratory research. Scientific knowledge backs up many parts of the operation. For example, the drilling bit can be lubricated by fluidised mud. A matter of trial and error to begin

FIGURE 2.5 SOME CONTRIBUTIONS OF SCIENCE TO MODERN LIFE



with, the use of lubricating muds has become more efficient and refined because scientists have investigated the flow behaviour of liquid mud in a laboratory including the use of mathematical models to represent the effects of varying conditions on the flow.

At the refinery each distillation and every chemical reaction has by now been thoroughly studied and the knowledge obtained fed back to improve the operation. Each of the products of the plant, say plastics, may be made by quite different reaction paths. Decisions on the efficiency, energy cost and other factors need a basis of scientific measurements before there can be confidence in the choice of the most suitable method. The product must again be tested from many angles before it is made available to the customer, although the extent of legislation to protect the interests of the consumer is still vary varied and is extremely lax in some countries.

These sorts of discrepancies in the law have led to serious personal and environmental problems when products, legally unacceptable in the country of origin, are dumped on the markets of less industrialised or developed countries. Science teacher educators and science teachers have responsibilities and opportunities to alert their students to these undesirable practices. Foods and food additives, pesticides and other agricultural products and pharmaceuticals provide examples of products of this hazardous type. Also as legislation has appeared to prevent the polluting effects of the effluent from various industries, such as manufacturing and mineral refining, the owners, often multinationals, have moved them to other societies which are not yet protected by these sorts of laws.

In a modern science-based industry, no part of the process should be left to chance. Even processes that had worked well for many years have been improved by application of scientific knowledge and the ideas of technologists. A great deal of effort by applied scientists is nowadays directed towards these long established practices in order to improve their efficiency, the quality of their products, or to see what alternatives can be developed as traditional raw materials become scarce and expensive.

There are two compelling reasons why science should contribute a monitoring role as well as a facilitating role in these industrial processes. The first arises from the widespread evidence in all types of countries that the employees have been suffering from hazardous conditions associated with the environment of production processes. Some of these, like the effects of asbestos, went undetected for many years. Even after these hazards have been well established, many companies still do not provide adequate safety precautions for workers. Scientists and technologists are needed to identify the presence of danger to humans in the increasingly complex situations of modern production. Constant vigilance and monitoring is needed, for example, to help workers protect themselves in the many industrial and medical work environments where dangerous radiation is used. When it is not possible to protect adequate safeguards the scientists and technologists must develop alternative procedures and remote control devices have been substituted for human beings in some of these high radiation situations.

The second monitoring role for scientists relates to the consumers and these need to take into consideration both the health of individuals and of the society as a whole. Biological and medical scientists often provide helpful evidence of the former that has led to the sort of protective legislation to which we have referred. Social health is less well understood and its part in environmental issues is only just beginning to be recognised.

Part B The Scientific Place in Technological Society

The knowledge world of formal education is subdivided and setmented into areas of speciality. Figure 2.6 indicates just how true this is for the worlds of science and technology. Some of these specialities are new and have a long way to go, but most have a well established body of knowledge. The specialists have extensive training, in which reading, experimenting, calculating and questioning play very major roles, prior to their experience in employment.

In this specialised world there seems little room for the non-expert to have an influential say. There is an inbuilt danger in the 'expert' society that people will perceive that the last word, on all sorts of issues that concern ordinary people, should be from the expert. This tendency can be used to silence the voice of the ordinary people whose lives will be affected by a particular technological innovation. It can even extend beyond the field of competence of the expert. Experts, themselves, used to guard against and be challenged in this extension of their useful role.

In practice, however, there have been many occasions when the voice of the expert is also not heard or acknowledged. Jacques Ellul in a book called Technological Society, describes a tyrrany of *technique* in which the requirements of technology become the ultimate determinants of mankind itself - individually and collectively - rather than technology being sets of tools whereby human beings serve and control their own needs and destiny.

In the large industries (petrochemical, electronic, food, etc.) of technological societies, the technologist is only one member of a huge team producing a wide variety of products. He/she may have more status and responsibility than a shop floor worker, but his/her influence on the overall policy of the company is often not much greater. The fact that the company scientist may be working on a development project which could be thought of as morally objectionable, (e.g. a nerve gas or bugging devices) is not seen as overly impressive when viewed in the context of the much wider range of good products and activities that the company handles.

The individual scientist or worker is buffered from the consequences of his/her action by a long chain of other processes and decisions that go on between the time of his/her contribution and the final objectionable use of the product. This is further complicated by the fact that there are inevitably some good uses of the product. For example nerve gas turns out to be an excellent treatment for some diseases of the eye, providing relief for thousands of people.

In this buffered state, scientists and technologists became less critical of their output and, indeed like most other workers, are very interested in the continuance of their employment. In this way, the very large number of these specialists involved in the industries of weapons development become a driving force for its continuation.

FIGURE 2.6 AREAS OF SCIENCE AND TECHNOLOGY

If only a fraction of world expenditures on weapons and the human resources involved in its research and development could be utilized on the issues of the environment, we would see great changes in societies across the world. Scientists and technologists are very active in many countries contributing to the resolution of environmental problems but the scale of this use of them is no where near that of the armaments effort.

The absorption of the scientist and technologist into *the system of production (Ellul's technique)* deprives them of the opportunity and the motivation to see their work and its possible consequences as something within their own sphere of personal responsibility and control. The company or even something wider becomes the unit of responsibility and control rather than the individual.

Research scientists in universities usually feel even further away from control of or responsibility for consequences of their work, but they too are part of *the system*, albeit at an earlier stage of its production line.

Just as many mass produced and processed foods have taken on a bland flavour and a soft texture to suit rather than satisfy all possible tastes, so the mixture of good and bad consequences of one's work and the anonymity of being part of a large institution, helps to generate a bland mixture of moral values designed to offend few and exhilarate even fewer.

The Technological Society also is designed in such a way that there is a diffusion of moral responsibility for the more objectionable aspects of technology. Hydrogen bombs are (presumably) not produced all under one roof. Many separate manufacturing sites all over the country each makes a small part of the total assembly - possibly even without workers realising the use of the bit they are producing. Each factory would make less offensive items so the impact of this one on the participants seems very minor. The final collection and assembly of the parts would only take place in maximum security conditions, with workers carefully chosen for their positive attitudes towards the project. Individual responsibility is totally diffused in a system like that, and even if the participant makes a conscientious objection, his/her role is usually not crucial to the overall plan and he/she can be replaced.

This unit sets out to assist teachers to gain confidence in their roles as interpreters to their students of the world of technology and of the ways scientists work, and of how they contribute to society.

<table>
<tr><td colspan="2">UNIT VIII: SCIENCE, SOCIETY AND TECHNOLOGY</td></tr>
<tr><td><u>Objectives</u>
(1) to develop students' understanding of what are the relations between science, technology and society.
(2) to assist them with teaching methods to include these inter-relationships in their science teaching.

<u>Preservice Teacher Needs</u>
(1) To gain confidence that science/ society has a place in science teaching
(2) To feel confident in the skills of teaching methods that are appropriate to this type of science teaching</td><td><u>Environmental Education Aims</u>
. to help students acquire an awareness of and sensitivity to the total environment
. to help students develop the skills necessary for investigating the total environment and for solving environmental problems
. to provide students with opportunities to be actively involved at all levels in working towards the resolution of environmental problems</td></tr>
<tr><td><u>Resources</u>
2 Worksheets and Figures 2.5 and 2.6
Access to library resources or to various scientists and technologists</td><td><u>Suggested Time</u>
3 sessions of 2 hours, plus time for information collection.</td></tr>
</table>

SUGGESTED APPROACH

Before embarking on the activities that relate to Parts A and B of the broad topic, the science teacher educator may wish to present the main ideas about how science, and technology interact and how they both influence society. This should be made very relevant to the teachers if an appropriate example for their own society is chosen.

Some of these ideas have been set out in the introduction to this unit but it is important that the science teacher educators highlight those aspects that are relevant in their own countries.

PART A

Activity 1

After the introduction in the first half of Session 1, the science teacher educator should trace the involvement of scientists in the production sequence of the following examples of modern technology. A more relevant local example can be substituted.

(a) an antibiotic drug

(b) a photographic film

(c) a transistor radio

(d) a cabbage or other vegetable for marketing in a distant place.

Using brainstorming or buzz groups, the class can be encouraged to speculate on some of the changes that science might bring to these processes in the future.

Activity 2

Following this introduction and the class discussion, each pre-service teacher is asked to select one of the inventions from Figure 2.5. As an assignment for the next session on this Unit, they are to collect information from the library, or from available experts (in other university or college departments or in government or industrial centres) so that the Worksheet sections are completed. These Worksheets, when completed, should be shared within their groups in the Session 2. One or two may be presented and discussed by the class as a whole.

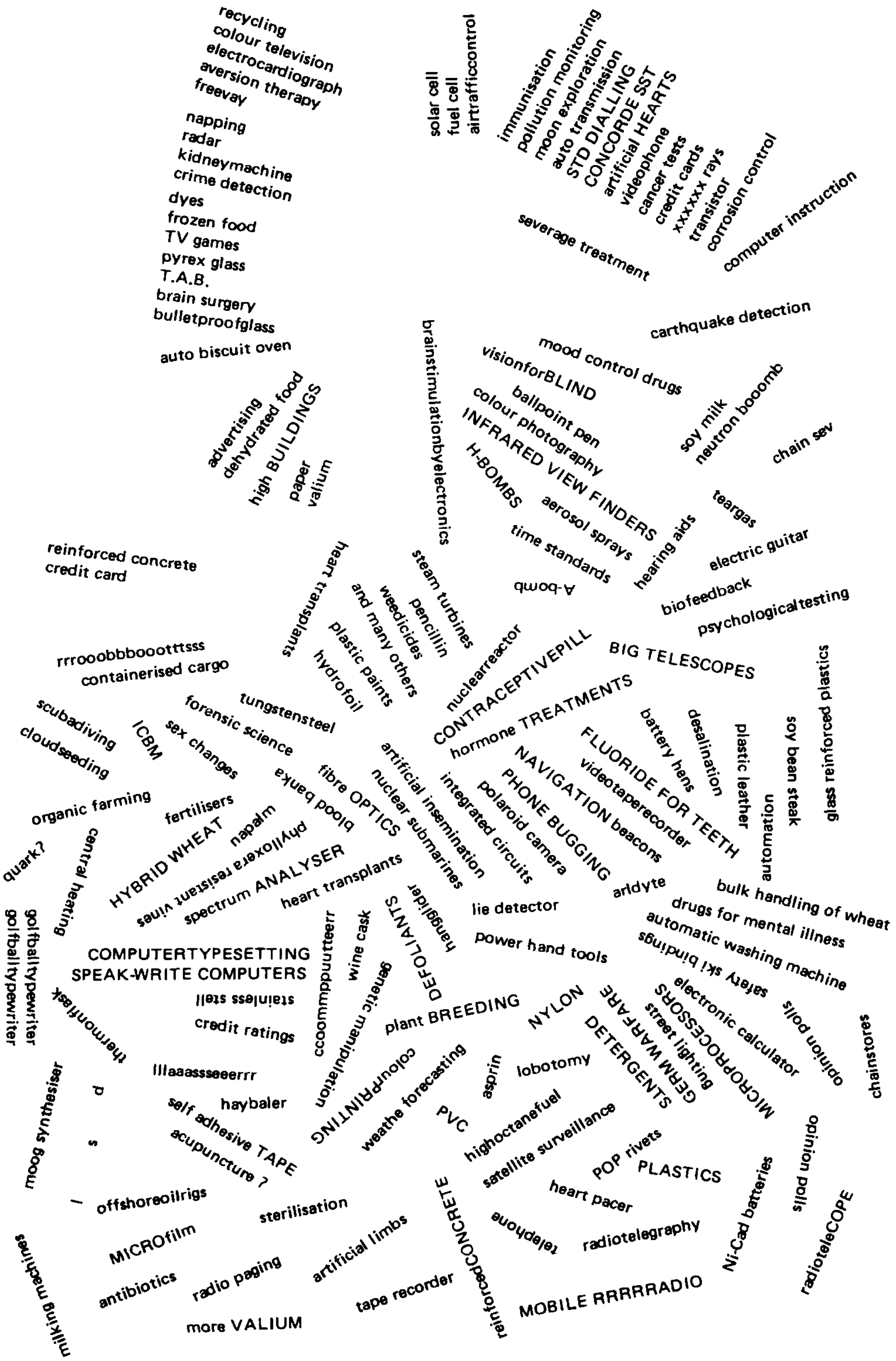
PART B

Activity 3

At the end of Session 2, each pre-service teacher is to select two of the sciences in the collage of Figure 2.6. One should be a science the teacher has studied and one should be an unfamiliar one. Before Session 3, using library sources or appropriate scientists, the questions on the Worksheet for Part B should be answered. Once again, in Session 3, these should be shared within the groups and some of them and the experiences of talking to the experts themselves should be presented to the whole class.

FIGURE 2.5 SOME CONTRIBUTIONS OF SCIENCE TO MODERN LIFE

WORKSHEET 1



WORKSHEET 1 (Contd.)

PART A Technological Society and its Related Science

Chosen Technology: ....

When technology was first available commercially in this country: ....

Where technology is used: ....

....

What raw materials are used: ....

Where do raw materials occur: ....

....

Underlying science principles: ....

....

....

Approximate dates when these principles were established: ....

....

....

Some of the scientists responsible for these principles: ....

....

....

What laws, if any, protect people against the abuse of such technology: ....

....

....

FIGURE 2.6 AREAS OF SCIENCE AND TECHNOLOGY

WORKSHEET 2

WORKSHEET 2 (Contd.)

PART B

Chosen Specialist Field of Science

What sorts of objects or events do specialists in this field study?	....
	....
What are some important concepts in this field of science?	....
	....
What are three applications or examples of technology that involve this field?	....
	....
Who are three internationally famous persons expert in this field?	....
	....
Who are two persons in your country expert in this field?	....
	....
What are three benefits to Society from this field?	....
	....
What is an environmental problem involving this field?	....
	....
	....

CHAPTER 3

CURRICULUM TASKS IN ENVIRONMENTAL EDUCATION FOR SCIENCE TEACHERS

INTRODUCTION

In seeking to expand the science teaching into the realm of environmental education, the most important requirement is the commitment and motivation of the teacher, not the method. After all, teaching is a very personal activity, the success of which frequently depends on the relationship that exists between teacher and student. When the emphasis of learning is solely on the acquisition of knowledge as frequently happens in science, the role of the teacher may well be taken over in the future by computer-assisted learning. In environmental education, the application of science is significant, the motivation for getting involved is important, and creative responses to real situations are being sought. In all of these, the role of the teacher is both crucial and personal.

The basic problem underlying all the various environmental issues is a question of values. There can be no greater misconception of environmental education than to believe it to be concerned only with the application of science to the problems of pollution, energy and endangered species. It is fundamentally concerned with the kind of people we are, the values we hold, and what we are to do to improve the world we and subsequent generations are to live in.

What follows is a set of suggested procedures by which science teacher educators can become involved in environmental education with their students. To work in practice, these procedures need to be followed sympathetically rather than slavishly. They will need to be adapted to the local situation. In due course, they should all be useful procedures for science teachers with their own pupils in secondary school.

At the end of the set of procedures (Units IX-XIV), there is an outline of how the problem of solid waste disposal could have been developed using them. The chapter finishes with a challenge which could be a check on both the skill acquisition and on the commitment that is being built up through the environmental learning. It takes the form of a junction event in which the group sets out together to communicate about an environmental issue to a chosen target audience.

UNIT IX

IDENTIFYING AN ENVIRONMENTAL PROBLEM

INTRODUCTION

The situations we now recognise as being environmental issues have often developed over a period of time as a result of new scientific and/or technological innovations. Frequently these were initially thought of as being beneficial with few or no perceived disadvantages. With the passage of time the environmental implications come to be recognised , by which time the whole issue is considerably complex. This occurs because of the many social, economic and personal factors that are involved.

One of the essential steps for sensible participation in the resolution of complex social issues is to be able to identify the environmental components involved. For example, the building of a dam for irrigation in a drought-stricken area is initially seen as most desirable. Years later when people are experiencing hardships, the dam is identified as one of the contributing causes of, for example, soil salination problems. The solution to this environmental problem, however, is now extremely difficult, compounded as it is by the dependence of the whole region on the dam, the economic problems being experienced by individuals and the administrative difficulties of getting something done about it.

This first planning unit is to help pre-service science teachers to recognise environmentally-related problems that occur in issues involving science. After mentioning local issues and recognising the science subject areas most closely involved, the pre-service science teachers are required to state the problem and identify whether it is related to the environment in some way. This process, combined with a numerical method of ranking them, helps the science teacher educator to select problems for possible ongoing study and action.

<table>
<tr><td colspan="2">UNIT IX: IDENTIFYING AN ENVIRONMENTAL PROBLEM</td></tr>
<tr><td><u>Objectives</u>
(1) to develop students' understanding of what are environmental problems
(2) to assist students in selecting appropriate environmental problems for inclusion in science lessons
(3) to develop a commitment to an environmental problem</td><td><u>Environmental Education Aims</u>
. to help students acquire an awareness of and sensitivity to the total environment
. to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems
. to help students acquire social values and strong feelings of concern for the environment
. to help students acquire the motivation for actively participating in environmental improvement and protection</td></tr>
<tr><td><u>Science Process Skills</u>
classifying, communicating</td><td><u>Pedagogical Techniques</u>
(i) teacher directed discussion,
(ii) buzz groups</td></tr>
<tr><td colspan="2"><u>Preservice Teacher Needs</u>
(1) to feel confident in identifying an environmental problem
(2) to feel that they can cope with the problem of selecting satisfactory environmental problems for investigation
(3) to provide the primary skill in introducing an environmental emphasis into their science teaching</td></tr>
<tr><td><u>Resources</u>
local/national newspapers over a limited period (a week)
worksheet</td><td><u>Suggested Time</u>
1 hour minimum - up to 2 hours, depending on the activities selected from the unit</td></tr>
</table>

SUGGESTED APPROACH

Step 1

A: student-centred

A week or so before the commencement of this unit the science teacher educator could ask the pre-service teachers to collect newspaper cuttings of local issues that they think have significant science and/or technological content. These are produced at the first session and the pre-service teachers are asked to state briefly why they chose their particular issues and to identify the science subject area associated with it. (Alternatively, pre-service science teachers could be asked without prior preparation to recall current issues of interest and identify the science content.) Enter in columns 1 and 2 on Worksheet.

OR

B: teacher-centered

The science teacher educator produces a list of local issues that he/she consideres has science and/or technological content and would be of interest to the pre-service teachers. They are then asked to identify the science subject area involved.

1	2	3	4
List of Science News Items	Areas of Science Involved	Problems Associated with News Items	Science Involved in the Problem

Step 2

The pre-service teachers are then invited to identify a problem associated with the news item they have chosen (or been given). They are then to state this on the Worksheet, (column 3) and indicate in column 4 whether or not the problem involves science content. These are collected and summarised by the science teacher educator in a master Worksheet table on the blackboard.

As an example of this process, the master Worksheet on the blackboard may now look something like this:

1 List of Science News Items	2 Area of Science Involved	3 Problem Associated with News Item	4 Science Involved in the Problem
A logging of forests	engineering biology	forests not being replaced	YES (biology)
B proposal to construct a new road	physics	threatens plant and animal species	YES (biology)
C invention simplifying building construction	physics	no identifiable problem	NO
D strike at a chemical factory	-	will temporarily increase pollution of river	YES (chemistry & biology)
E construction of a food processing factory	physics engineering	displaces subsistence farmers	NO

Step 3

The science teacher educator describes how science involves a problem-solving approach and therefore it can be applied to the problems arising out of the issues that have already been brought forward. Not all problems are environmental. It is explained to the pre-service teachers that for a problem to be environmental it must relate to one or other of:

energy, ecology, resources, food, pollution, population.

Step 4

The pre-service teachers are then placed into buzz groups * and asked to identify those problems which are environmental. In this process it may be necessary for the original wording of the problem to be revised so that its environmental nature is made clear. These are entered in columns 5 and 6. The outcomes are again collected and summarised by the science teacher educator in the master Worksheet.

* see Chapter 4 on this procedure

As an example of this process, the master Worksheet on the blackboard may now look something like this:

3 Problem Associated with News Item	4 Environmental Category	5 Problem Re-stated as Environmental Problem
A forests not being replaced	resources	how can we be assured of an adequate continuing supply of wood?
B threatens plant and animal species	ecology	is it possible to conserve the threatened species?
C deleted		
D will temporarily increase pollution of river	pollution	is it possible to prevent the pollution of the river?
E displaces subsistence farmers	population	can the farmers or the factory be relocated elsewhere?

Step 5

To select a suitable environment problem for study and action by the whole class as a group (or even an individual if the science teacher educator so decides), the following list of criteria is distributed to the class:

1 : can this problem be readily related to topics in the science curriculum? (maximum score = 10)

2 : are information resources (people, books, documents, etc.) readily available? (maximum score = 6)

3 : does the problem interest you? (maximum score = 5)

4 : is the problem significant? (maximum score = 5)

5 : is the problem relevant to you as a pre-service teacher? (maximum score = 4)

It is possible that the science teacher educator would like to change the weighting of the various criteria after discussion with the class. In addition, other criteria might be added.

Each buzz group is then asked to complete the Worksheet and present their rank order to the whole class.

An example of a completed Worksheet may look like this:

Environmental Problem	Criteria for Selection 1 (10)	2 (6)	3 (5)	4 (5)	5 (4)	Total Score	Rank
A how can we be assured of an adequate continuous supply of wood?	6	3	5	5	4	23	1
B is it possible to conserve the threatened species?	8	5	5	3	2	23	1
C deleted	-	-	-	-	-	-	
D is it possible to prevent the pollution of the river?	7	4	3	4	2	20	2
E can the farmers or factory be relocated elsewhere?	1	2	1	3	4	11	3
F							
G							

Step 6

If buzz groups differ in the priority given to particular problems, or two problems are given the same priority by the same buzz group, a spokesperson is asked to justify their selection and ranking.

Step 7

Optional: Having decided how many problems are going to be undertaken by the class for follow-up in subsequent sessions, the science teacher educator selects them from those given high priority by the group.

UNIT IX

IDENTIFYING AN ENVIRONMENTAL PROBLEM

STUDENT WORKSHEET

INTRODUCTION

The situations we now recognise as being environmental issues have often developed over a period of time as a result of increasing new scientific and/or technological innovations. Frequently these were initially thought of as being beneficial with few or no perceived disadvantages. With the passage of time the environmental implications come to be recognised, by which time the whole issue is very complex. This occurs because of the many social, economic and personal factors that are involved.

One of the essential steps for sensible participation in the resolution of complex social issues is to be able to identify the environmental components involved. For example, the building of a dam for irrigation in a drought-stricken area is initially seen as most desirable. Years later when people are experiencing hardships, the dam is identified as one of the contributing causes of, for example, soil salination problems. The solution to this environmental problem, however, is now extremely difficult, compounded as it is by the dependence of the whole region on the dam, the economic problems being experienced by individuals and the administrative difficulties of getting something done about it.

This first planning unit is to help you to recognise environmentally-related problems that occur in issues involving science. After mentioning local issues and recognising the science subject areas most closely involved, you are required to state the problem and identify whether it is related to the environment in some way. This process, combined with a numerical method of ranking them, helps to select some of these problems for ongoing study and action.

Stating real issues as problems and identifying the science involved.

1	2	3	4
List of Science News Items	Area of Science Involved	Problems Associated with News Items	Science Involved in the Problem
A			
B			
C			
D			
E			
F			

Application of Broad Environmental Categories as Criteria.

Is the problem related to: energy, ecology, resources, food, pollution, population?

3	5	6
Problems Associated with News Item	Environmental Category	Problem Re-stated as Environmental Problem
A		
B		
C		
D		
E		
F		

Application of Criteria for Selecting a Problem to Society.

Give each problem a score on the following criteria:

1. can this problem be readily related to topics in the science curriculum? (maximum score = 10)

2. are information resources (people, books, documents, etc.) readily available? (maximum score = 6)

3. does the problem interest you? (maximum score = 5)

4. is the problem significant? (maximum score = 5)

5. is the problem relevant to you as a pre-service teacher? (maximum score = 4)

UNIT X

COMMENCING AN INVESTIGATION INTO AN ENVIRONMENTAL PROBLEM

INTRODUCTION

Problems, like those associated with the environment are characterized by their complexity. This is because any significant issue is not just a product of recent scientific and technological advances but also of the whole social context within which it occurs.

At times the immensity or difficulty of the task can be seen as overwhelming. For the would-be researcher into an environmental problem there are however three strategies which can collectively reduce the task to something that is more manageable.

The first strategy is to define carefully the basic information being sought. This can best be done in the form of specific questions for which answers are being sought, which then act as a guide for the work that follows.

The second strategy is to identify the known and potential sources of answers to the questions that have been formulated. While in some cases it may not be possible initially to be specific as to who to turn to, it can be enough to recognise that institutions like government departments, universities, local government councils, public libraries, private industry or the media can be sources of assistance. In addition to identifying various sources of expertise, there is the information to be gained from the actual locality in which the problem occurs. Finally there is the important contribution made by books, references and reports which if available, contain much that is relevant.

The third strategy is to join with at least one or two others to tackle the same problem. Such a pooling of human resources not only reduces the work load for any individual but allows people with different skills and experience to interact and encourage each other while being more efficient in the use of time and effort.

This unit is designed to provide a structure for the students' approach to the investigation of a problem, using each of the three strategies just outlined.

UNIT X : COMMENCING AN INVESTIGATION INTO AN ENVIRONMENTAL PROBLEM

Objectives

(1) to help students develop a greater appreciation of the nature of science and the need to identify relevant sources of information

(2) to promote a team approach to the investigation of problems

(3) to increase student appreciation of some of the relationships between science and society

Environmental Education Aims

. to help students develop a basic understanding of the total environment and the interrelationships of man and the environment

. to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems

. to help students acquire social values and strong feelings of concern for the environment.

Science Process Skills

questioning, classifying, communicating, interpreting data

Pedagogical Techniques

(i) small group discussion
(ii) committe

Preservice Teacher Needs

(1) to feel confident in investigating an environmental problem

(2) to feel that they can join as a member of a team in undertaking an environmental problem

(3) to feel that they have a better understanding of the nature of an environmental problem

Resources

a list of information-seeking questions (for part B), worksheet, and whatever else is required by the students in carrying out their task

Suggested Time

Phase I: Getting started
1 hour plus time for committees to get organized

Phase II: Information gathering, Monitoring Progress
15-30 minutes each week for 4-6 weeks

Phase III: Reporting and Collating the Information
1 hour or more depending on the number of questions being investigated, the complexity of the problem and the number of students involved

SUGGESTED APPROACH

PHASE I:

Getting Started - An environmental problem is either given by the science teacher educator, or selected through the process outlined in Unit IX.

Step 1

A: student-centred

In small groups of approximately 4-6, the pre-service teachers are asked to produce a list of questions which collectively summarise the information they consider is required concerning the environmental problem being investigated.

OR

B: teacher-centred

The science teacher educator provides a list of the questions which collectively summarise the information he/she considers relevant to the environmental problem being investigated. The pre-service teachers are then asked to suggest any further questions which they consider relevant.

Step 2

The pre-service teachers are then asked to classify the questions using two different criteria: (i) science or social, and (ii) cause or effect. Science questions relate to the physical, biological and technological aspects of the problem, while social questions relate to people and the general social situation in which the problem has arisen. (See the examples given in the environmental problem at the end of Unit XIV.) This can be recorded on individual worksheets or done directly by the class onto a master Worksheet on the blackboard.

Step 3

The science teacher educator explains how science develops by the recording of information and ideas. For any problem, scientific or environmental, there already exists a body of knowledge of varying relevance. As it is impossible to know in advance in either field all the problems in which one is likely to be interested, it is desirable not only to have mastered a certain number of key concepts, but also to possess the skills to find out how and where further information may be obtained. In addition to the scientific literature and associated reports, relevant information can be obtained by observation and measurement from the locality in which the problem occurs as well as from people involved with the problem. These people include those at or near the location of the problem whose actions cause and/or who are affected by it, and experts who propose and have responsibility to control the problem, but who may live quite removed from the problem area.

Step 4

The pre-service teachers (as a group or individually, depending on time and the number of questions that have been produced) are asked to identify the best or most likely source of information for each of the questions that have been posed, and to record it in a table as follows. (The more specific the source identitified, the better.)

Questions	Science or Social	Cause or Effect	Possible Source of Answers Liter-ature	Location	Experts
1.					
2.					
3.					
4.					
5.					

Step 5

To co-ordinate the information-gathering and assign responsibility for it, the pre-service teachers are arranged into three committees, each one being responsible for obtaining as much of the information as possible from one of the three sources. (The science teacher educator has the responsibility of indicating the amount of time available for this phase of the investigation.) That is, one committee of the pre-service teachers will be responsible for the literature informaiton, one for information from the locality and one for the experts.

PHASE II: Information-Gathering, Monitoring Progress

Even in situations where the science teacher educator chooses to permit pre-service teacher to work fairly independently, it is advisable to review their progress regularly. This is necessary for two reasons: to set an example to the pre-service teachers who, when they repeat their experience with their students will have to monitor them closely because they will be younger and less experienced; and because it allows the pre-service teachers to receive feedback on the expectations of the science teacher educator relating to progress in working on the environmental problem.

During this information-gathering phase it might be found necessary for individuals or whole committees to do one or more of the following:

(i) revise skills in conducting library research.

(ii) conduct a field trip.

(iii) interview people.

(iv) write letters (to individual experts, organisations, government departments, etc.).

(v) prepare a survey or questionnaire.

(vi) carry out laboratory tests.

It is not possible here to elaborate on all these skills in detail, but because of the importance of field trips to environmental education, this aspect is discussed more fully in Unit XVI.

In relation to preparing questionnaires and interviewing people generally, the science teacher educator would be well advised to suggest that time be spent by the pre-service science teachers in working out their questions precisely before using them. There are at least three common faults associated with questioning as generally carried out by people seeking information. The most common one is to ask questions which are irrelevant, i.e., they could be better answered by a different person or source. When people agree to being interviewed by students, it is a courtesy on their part to come prepared. The second problem is associated with the clarity of the question. What is understood by the person asking the question might be misunderstood or unclear to the person being interviewed. The proposed question could easily be pre-tested by one student asking another to explain what he/she understands by the question. The third problem is that of asking two questions in one sentence, e.g. is the pollution in that river harmful and difficult to control? Any short answer can lead to confusion as to what is exactly meant by the question and how the answer is to be interpreted.

<u>PHASE III</u>: Reporting and Collating the Information

After the allocated period of time for information-gathering has elapsed, it is necessary to share and collate it with the whole group. This is done by asking each of the questions in turn posed at the outset of the investigation (along with any others that have arisen since), and individuals and groups from the respective committees who have anything to contribute are given the opportunity to report.

One way of giving some order to the information-sharing is to deal with all the questions that are in the same social/scientific and cause/effect category. Thus information could be presented in answer to the questions in the following order of category:

social:	cause
scientific:	cause
scientific:	effect
social:	effect

Such an arrangement emphasises the social and environmental context in which problems occur.

For each question the group, as a whole is asked to identify any contradictions that may have become apparent in the reports from the committees using different sources. These are to be identified as contradictions of fact or as differences in interpretation. In the case of the former, discrepancies will have to be resolved (e.g.checking original sources), whereas differences in interpretation can only be recognised as such and treated accordingly.

Although additional information continues to become available the completion of this phase means there is to be a change of emphasis from finding out more about the problem to considering what can be done about it. While the thought that not all is yet known about the problem may be of concern to some students (and to science teacher educators), it is not always possible in the real world to delay social action until all the information is at hand. This situation has long been recognised for in the words of Aristotle:

> "The ultimate end... is not knowledge, but action. To be half right on time may be more important than to obtain the whole truth too late."

UNIT XI

PROPOSING AND ELABORATING ON POSSIBLE SOLUTIONS

INTRODUCTION

Environmental problems and issues are rarely simple with a self contained cause that can easily be altered or eliminated. More often they involve very interactive causes that have ecological, social, economic and political associations and consequences as well as more scientific or technological ones.

Because of this complexity, it is possible that much of the information that can be gathered about a problem may not be directly relevant to proposing solutions to it. The information that science teachers are best able to gather will relate to scientific or technolocigal aspects of the problem, but these may not be the most significant ones for the solution since social and economic interests can often mean that different individuals see the "same" situation quite differently.

Accordingly, it is not expected that pre-service science teachers come up with the "right" answer. In this unit, they will, however, have the opportunity to appreciate that some proposed solutions are untenable, some are inappropriate, and some are possible.

UNIT XI : PROPOSING AND ELABORATING ON POSSIBLE SOLUTIONS	
Objectives (1) to develop students' appreciation of the numerous possible ways of dealing with environmental problems (2) to develop students' understanding of the possible ramifications of any proposed solution to an environmental problem (3) to assist students in appreciating individual differences in perceiving the consequences of any proposed solution to an environmental problem Science Process Skills classifying, communicating, inferring and predicting	Environmental Education Aims . to help students develop a basic understanding of the total environment and the interrelationships of man and the environment . to help students identify alternative approaches and make informed decisions about the environment that recognize ecological, political, economic, social and aesthetic factors Pedagogical Techniques (i) small group discussion (ii) brainstorming (iii) debate
Preservice Teacher Needs (1) to feel confident in handling complex environmental problems (2) to feel that they have developed an understanding of the complexity of environmental problems (3) to become aware of individual differences in reactions to environmental problems and how to begin to accept them	
Resources worksheet I and worksheet II	Suggested Time either three 1 hour sessions or 2 hours followed by another one hour to allow for a debate

SUGGESTED APPROACH

Step 1

The science teacher educator presents the class with a summary of an environmental problem containing a range of information that relates to the nature of the problem, to the social context in which it occurred, and to its effects. The problem presented can be one selected by the science teacher educator, one that the pre-service teachers have already been working on (see Units IX and X) or one based on the case study included after Unit XIV.

Step 2

The pre-service teachers are placed into small groups (approximately 5-10), and through brainstorming propose as many solutions as possible for the environmental problem. The suggestions may be ones that have already occurred to the pre-service science teachers, or ideas generated on the spur of the moment; they may also be strictly scientific or broadly social in nature. During a set period of time (say 10-15 minutes) all suggestions are recorded with no consideration given at this stage as to their merits or cost.

Step 3

The science teacher educator then asks the small groups to report to the whole class their suggested solutions, and a master list of the different proposals is made on the blackboard.

Step 4

The science teacher educator then explains to the class that the consequences of implementing any particular solution can vary considerably. An explanation (with examples) should then be given to illustrate the possible sorts of consequences that might occur. To each proposed solution, the pre-service science teachers are asked in small groups of 2-4 (depending on the size of the class and the number of proposed solutions), to infer what all the consequences might be, assuming the proposed solution was actually implemented. The inferences for each proposed solution are recorded by each member of the group in a separate table, like Table 1 on the Unit Worksheet.

Step 5

On completion of the set of Table 1, for the proposed solutions, the science teacher educator asks each pre-service science teacher to use Table 2 on the Worksheet to rate each of the consequences for the proposed solution on a 5-point scale:

(1) positively desirable

(2) mildly desirable

(3) consequences insignificant or positive aspects offset by negative aspects

(4) mildly undesirable

(5) positively undesirable

(For some consequences, an alternative to the 5-point scale may be more appropriate. If so, the science teacher educator can change it accordingly.)

This can be repeated for another group's proposed solutions by having the pre-service science teachers exchange copies of their Table 1, with those of another group.

Step 6

After the pre-service teachers have had an opportunity to note the consequences of most, if not all the proposed solutions, a class summary can be produced by the science teacher educator by extending the master table of proposed problems on the blackboard in the following manner:

MASTER TABLE OF PROPOSED SOLUTIONS

(summarising pre-service science teacher ratings of the consequences for different proposed solutions)

Proposed Solution	Consequences					
	ecological	economic	aesthetic	scientific	social	other
1.						
2.						
3.						

N.B. Record the ratings for each consequence in a systematic manner (in columns or rows) in the boxes under each of the broad headings.

Step 7

The class can now discuss:

1. differences in rating that occurred for the same consequence for a proposed solution.

and 2. which solution would seem to be most desirable ecologically, and (say) economically or socially. Are they the same? If not, which solution is to be preferred? Is that the solution that is most likely to be implemented?

Step 8

Following the class discussion, the science teacher educator can arrange for two (or more) groups to prepare detailed arguments in support of one or more of their preferred solutions.

These are to be presented to the class (or an even wider audience, including other students, teachers and parents if circumstances permit) on an occasion at which some non-science expert(s), e.g. ecologist, economist, social scientist, or politician has been specifically invited. After the groups have presented their arguments, the guest expert is asked to evaluate the proposals from the point of view of his/her particular expertise and to comment on aspects in that field that the pre-service science teachers could not be expected to appreciate fully.

WORKSHEET

INTRODUCTION

Environmental problems and issues are rarely simple with a self contained cause that can easily be altered or eliminated. More often they involve very interactive causes that have ecological, social, economic and political associations and consequences as well as more scientific or technological ones.

Because of this complexity, it is possible that much of the information that can be gathered about a problem may not be directly relevant to proposing solutions to it. The information that science teachers are best able to gather will relate to scientific or technological aspects of the problem, but these may not be the most significant ones for the solution since social and economical interest can often mean that different individuals see the "same" situation quite differently.

Accordingly you are not expected to come up with "the right answer". In this unit, you will, however, have the opportunity to appreciate that some proposed solutions are untenable, some are inappropriate, and some are possible.

TABLE 1 - CONSEQUENCES OR PROPOSED SOLUTIONS TO ENVIRONMENTAL PROBLEMS

Problem:	
Suggested Solution:	
Consequences: 1. ecological	
2. economic	
3. political	
4. aesthetic	
5. scientific/ technological	
6. social (number of people adversely affected and their social class)	
7. other	

TABLE 2 - RATING OF DESIRABILITY OF CONSEQUENCES OF PROPOSED SOLUTION

Proposed Solution	Consequences						
	ecolog- ical	econo- mic	polit- ical	aesth- etic	scien- tific	social	other
1.							
2.							
3.							

N.B. Rate each consequence that is recognised under each of the headings.

UNIT XII

DO I WANT TO GET INVOLVED?

INTRODUCTION

Science would not have become the powerful, elegant and intriguing body of knowledge and skills that it has if scientists throughout the ages had not been willing to try out their ideas and to explore their questions. Science, as we know it, is in fact the field of knowledge that derives its truths and falsehoods from experience - the putting to the test of its ideas and theories.

But science does not stop at producing knowledge about some phenomena. Other scientists often then move in and try to use the knowledge to solve practical problems to find new of doing things or simply to improve on existing procedures.

In the case of environmental problems facing the world we are now at a time in history when we no longer have the option of saying there is no problem. There are problems to solve or else they will get worse and become irreversible. Since the dropping of the atomic bomb on Japan in 1945, there has been a rising conscience among scientists all over the world. The Social Responsibility of Scientists is now an international movement. It is also a phrase that has begun to appear in school science curricula since the early 1970s.

This unit is concerned with ways of raising this challenge of social responsibility in science classes. In doing so, it is important that the science teacher does not push one line of action or one solution only. Other teachers, like those in humanities and social science, are more accustomed to controversial issues in the classroom and their experience will also be a help to science teachers when they face this aspect of their environmental teaching.

UNIT XII : DO I WANT TO GET INVOLVED?	
Objectives (1) to assist students in expressing facts, opinions and associated feelings in relation to an environmental problem and its proposed solutions (2) to assist students in identifying their own feelings towards a particular environmental problem	**Environmental Education Aims** . to help students acquire an awareness of and sensitivity to the total environment . to help students acquire social values and strong feelings of concern for the environment . to help students acquire the motivation for actively participating in environmental improvement and protection
Science Process Skills communicating	**Pedagogical Techniques** (i) small group discussion (ii) teacher-directed discussion (iii) role-playing
Preservice Teacher Needs (1) to recognise that both scientific investigation and people's feelings are involved in teaching environmental problems (2) that it is acceptable and necessary for feelings about a problem to be expressed if the problem is to be more fully understood	
Resources a summary of the problem and an outline of two possible solutions space in which to act out a public meeting	**Suggested Time** a 2 hour session (with the possibility of an additional 1 hour session for more discussion).

SUGGESTED APPROACH

Step 1

A: introducing a new problem

A few days or so before the commencement of this unit the science teacher educator could distribute to the class a summary of an environmental problem, along with the outline of at least two proposals for resolving the problem. Having read the summary, the pre-service teachers commence the unit in small groups and are asked to identify significant individuals or groups of people (both scientists and those in the environmental situation) involved in the problem and its proposed solutions. The science teacher educator collects the suggestions made by the small groups and produces a comprehensive list on the blackboard.

B: using a problem already investigated by the class

The science teacher educator summarises the problem and its proposed solutions, and asks the pre-service teachers to identify significant individuals or groups involved with it. These are listed on the blackboard.

Step 2

Each significant group or individual is then allocated to a small group of pre-service teachers who are asked to spend about 15 minutes outlining:

(1) personal characteristics, e.g. age, sex, qualifications, experience, personality

(2) the main points that define his/her/their position in relation to the problem and the proposed solutions

(3) possible feelings that such a person either as an individual or as representative of a group, might have towards the problem and the proposed solution.

Step 3

Having allocated a number of the pre-service teachers to take the part of an individual or group representative involved in the environmental problem role play the following situation: "a public meeting has been called to assess support for the proposed solutions". The purpose of the activity is to allow a range of feelings to be expressed along with relevant facts and opinions.

Step 4

Following the enactment the class is invited to discuss what happened, how realistic the role-playing was, and to what extent the feelings expressed were akin to their own.

Step 5 (optional)

Re-enact the situation with different students in the various roles, expressing different feelings. Discuss it on completion and compare with the first one.

Step 6

In small groups, pre-service teachers are asked to discuss: "how do you feel about actually becoming involved and doing something to reduce the problem?".

Step 7

Follow up the small group discussion with a class discussion (or individual written reports) on:

"What is our social responsibility towards resolving this environmental problem

(a) as scientifically literate members of the community?

(b) as teachers?

(c) as individual persons?"

UNIT XIII

IDENTIFYING POSSIBLE STRATEGIES FOR SOCIAL ACTION

INTRODUCTION

Many scientists are under the impression that the resolution of a problem depends on having a scientific solution. When this has been found through diligent research, then they tend to expect that its implementation will or ought to follow. In practice, such a view of the workings of a society is naive and ultimately counter-productive. Scientific research may indeed be necessary as a contribution to the resolution of many problems in society, particularly environmental problems. It still, nevertheless, has to become accepted by decision-makers and those members of the society who are affected by the problem.

Such acceptance does not come by chance but has to be argued for, frequently in the face of alternative courses of action, which may or may not be as effective or desirable technically. In seeking acceptance of a technical solution, it is necessary for its supporters to demonstrate its contribution to social well-being. This can only be achieved by identifying both those who will benefit by its implementation and those who have to make the decision.

To reach these beneficiaries and the decision-makers, a number of methods could be utilised. Such methods or social strageties range from letter-writing to personal interviews, from street demonstrations to articles in the local newspaper. Each possible avenue for social action has advantages and disadvantages and these will depend very much on the social, political and cultural context of a given country or state. More importantly some strategies are likely to be more effective than others. Because such strategies have as their goal some change in present society, successful experience of their use produces citizens who no longer feel oppressed or ineffective. Involvement in this sort of social action therefore promotes the development of a sense of participation in the decision-making processes that underlie social change.

As environmental aspects of resource use, food production, pollution, energy consumption and population growth continue to threaten the ultimate well-being of all people, such informed participation and experience with social change is more urgently required.

The purpose of this unit is to commence the formulation of possible strategies for social action.

UNIT XIII : IDENTIFYING POSSIBLE STRATEGIES FOR SOCIAL ACTION	
<u>Objectives</u> (1) to assist students in identifying a range of possible social actions (2) to develop student awareness of the potential difficulties associated with social action (3) to help students choose appropriate forms of social action in relation to a particular environmental problem	<u>Environmental Education Aims</u> . to help students acquire the motivation for actively participating in environmental improvement and protection . to help students identify alternative approaches and make informed decisions about the environment based on ecological, political, economic, social and aesthetic factors . to provide students with opportunities to be actively involved at all levels in working towards the resolution of environmental problems
<u>Science Process Skills</u> communicating, inferring and predicting	<u>Pedagogical Techniques</u> (i) teacher directed discussion (ii) small group discussion (iii) brainstorming (iv) debate
<u>Preservice Teacher Needs</u> (1) to feel confident in identifying a form of social action (2) to feel that they can cope with the selection of appropriate forms of social action in their own context	
<u>Resources</u> a list of possible social actions a number of problem cards (perhaps 6 or so) on which there is an outline of a problem and a proposed solution	<u>Suggested Time</u> 2 hours - depending on the activities selected from the unit

SUGGESTED APPROACH

<u>Step 1</u>

The science teacher educator presents to the pre-service teachers a summary of the nature of Environmental Education (see Unit IV) and stresses in particular the significance of social action.

Step 2

A: structured approach

Give each pre-service teacher

(1) a list of possible social actions

and (2) a card on which an environmental problem and a proposed solution is outlined.

Their task is to list, for each proposed solution, as many different forms of social action that they consider appropriate. These suggestions can be derived from the social action list but they should be encouraged to add their own additional ideas. (The process can be repeated by having the pre-service teachers change cards.) After a suitable time has elapsed (say 15-20 minutes) the class can be asked to present their suggestions for each problem card, and an extended list of different forms of social action can then be constructed. Where there is disagreement about the suitability of particular social action for the same problem, the proponents should have to defend their choice.

B: unstructured approach

Arrange the class into small groups and give each group a card on which an environmental problem and a proposed solution is outlined. Their task is to brainstorm and produce a list of as many different forms of social action as possible that they, as a group, consider appropriate. After a suitable time has elapsed (say 15-20 minutes) the groups can be asked to assist in building up a class list of different forms of social action.

Step 3

Reform small groups and with a different problem card, look at the extended class list and

(1) choose appropriate forms of social action

and (2) rank them according to

(i) cost

(ii) anticipated effectiveness

(iii) time required for implementation

(iv) personal appeal

(v) suitability for pre-service science teachers (and/or suitability for primary and secondary school students)

Step 4

Exchange problem cards between small groups and repeat Step 3.

Step 5

Groups can then be asked to compare their rank ordering of forms of social action for the different categories and discuss any differences that arise.

Step 6

If a particular environmental problem is being pursued by the class, they could select the forms of social action that they will undertake for it

OR

The class should discuss the question:

> "what is the role of the science teacher in encouraging and being involved in various forms of social action in a school situation where an environmental emphasis is included?"

OR

The class should debate

> "that appropriate social action on the part of school students should be encouraged by the teacher (and/or the school) in association with their study of environmental issues."

UNIT XIV

EVALUATION OF SOCIAL ACTION

INTRODUCTION

In science, all ideas or theories are in the end put to a test of experiment or the observation of the behaviour of nature. Without the honesty to apply these tests we would have no reliable science.

In planned social action there is a need, likewise, for some means of assessing the merits of various proposals and for criteria which, when the chosen actions occurs, enables us to appraise its worth. Only by such an evaluation can we learn to be more effective as citizens in contributing to the decision-making that is increasingly needed in relation to environment problems.

This unit explores the types of criteria that may be applied in different social contexts and the possible outcome of applying them to actual proposals for social action.

<table>
<tr><td colspan="2">UNIT XIV EVALUATION OF SOCIAL ACTION</td></tr>
<tr><td><u>Objectives</u>
(1) to help students in selecting appropriate forms of social action
(2) to assist students in increasing their general awareness of the nature of environmental problems and the effectiveness of action being taken to resolve them</td><td><u>Environmental Education Aims</u>
to provide students with opportunities to be actively involved at all levels in working towards the solution of environmental problems</td></tr>
<tr><td><u>Science Process Skills</u>
classifying, communicating</td><td><u>Pedagogical Techniques</u>
(i) brainstorm
(ii) small-group discussion</td></tr>
<tr><td colspan="2"><u>Preservice Teacher Needs</u>
(1) to feel that they can cope with the selection of appropriate forms of social action
(2) to feel that they are growing in understanding and competence in matters pertaining to science and environmental education</td></tr>
<tr><td><u>Resources</u>
copies of the list of Criteria for Environmental Action Selection</td><td><u>Suggested Time</u>
1 hour, and 1 hour later for discussion.</td></tr>
</table>

SUGGESTED APPROACH

Step 1

The science teacher educator explains to the class that the purpose of this activity is to produce a list of criteria which could be used in selecting and implementing possible forms of social action.

Step 2

The pre-service teachers are asked to individually "brainstorm" and list on a piece of paper as many suggestions as possible as to the criteria that might apply. These are then collected and made into a class master list.

Step 3

The class is then divided into small groups which examine the master list and

(1) identify those that are similar or are included under a larger criterion

(2) eliminate those that are redundant or restate the criterion in another way

Step 4

Allow time for thinking and reconsideration, permitting discussion to continue until the group is satisfied with the list.

Step 5

Once the small groups have refined their list of criteria, they should be shared and discussed by the entire class. Criteria developed by the small groups should be cross-checked to make the final class list as complete as possible.

Step 6 (optional)

The class list could be compared with the following criteria:

Criteria for Environmental Action Selection*

1. Is there sufficient evidence to warrant action on this issue?

2. Are there alternative actions available for use?

3. Is the action chosen the most effective one available?

4. Are there legal consequences of this action?

5. Will there be social consequences of this action?

6. Will there be economic consequences of this action?

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* Adapted from Hungerford, H.R. and Peyton, R.B. Teaching Environmental Education. Portland, Maine, J.W. Walch Publishing Company, 1976.

7. Do my personal values support this action?

8. Do I understand the procedures necessary to take this action?

9. Do I have the skills needed to take this action?

10. Do I have the courage to take this action?

11 Do I have the time needed to complete this action?

12. Do I have all the other resources needed to make this action effective?

13. What are the ecological consequences of this action?

Step 7

Allow the class to discuss how the criteria could be applied in selecting appropriate forms of social action.

Step 8

Encourage the class to carry out one of the selected appropriate actions in relation to an environmental problem with which they are concerned.

Step 9 (after completion of the Unit)

If time and circumstances permit, the science teacher educator may arrange for a discussion on the effect of any social action undertaken by the students. A discussion might cover such points as:

(i) Does such experience suggest any changes to either the list of criteria or the way in which it can be utilised to determine appropriate action.

(ii) Effectiveness of social action is hard to measure.

(iii) It takes time for social change to occur - why?

(iv) The most significant feature of the social action taken could be the experiences of the students, and the commitmnet (or otherwise) they make to environmental education.

EXEMPLARY CASE STUDY: SOLID WASTE DISPOSAL

INTRODUCTION

The problem of solid waste disposal could arise in the school classroom situation during work on a general topic such as "Science, Technology and the Environment", but it is more likely to be mentioned as an area of application when science teachers cover more specific topics such as

electromagnetism

mixtures and compounds

biogeochemical cycles

mining and its products

All of these, and others, could initiate an investigation into the problem of solid waste disposal if the science teacher was willing to permit it. (The scope and time allowed for this could be increased if the teacher of another subject, e.g. social studies, health, or geography, was prepared to join in too.)

How a classroom science teacher may be prepared to develop such an opportunity to become involved in environmental education can be illustrated by using this topic as an exemplary problem, and is presented so as to show how it might develop through the curriculum stages as outlined in the Units IX-XIV. The example, however, will cover directions that go beyond, and at greater depth, than most science teachers may consider appropriate, depending on their goals and the constraints of the science teaching situation.

Stage 1

Depending on how the problem of solid waste disposal actually arises in the classroom, it may or may not be necessary to help students recognise the science involved. If it arises as an application of science concepts already being taught, the problem immediately becomes one to be investigated (Unit X). However, if it is necessary to show this to be an environmental problem to which science can make a contribution, it could be dealt with such that it appears like this (from Unit IX):

Science Item	Areas of Science involved	Problem Associated with Science	Science involved in the Problem	Environment Category	Problem Restated as Environmental Problem
The amount of solid waste is increasing	physics, engineering, chemistry	represents wasted resources represents increasing danger from materials that have harmful characteristics such as radioactivity	physics: (1) use of (electro-) magnets to sort out ferrous from non-ferrous materials. (2) differentiating between materials with different densities. chemistry: (3) achieving separation through dissolving and sedimentation. biology: (4) organic substances can be broken down by bacteria and other decomposers. ecology: (5) in recognising that recycling, a process carried out by nature, can be imitated by people.	resources	can we reduce the amount of resources being wasted?

The prime focus of the problem will depend on how the problem arises. It could be limited to problems of sorting and separation of metal materials, or more broadly concerned with the application of science in general to the whole problem.

Stage 2

As suggested in Unit X, the following is a list of the questions which largely summarises the information which might be considered relevant to the problem of solid waste disposal:

(1) What is being thrown away?

(2) How can these items be classified?

(3) What is the quantity of each category being thrown away - say weekly?

(4) What is the best unit to measure the amount being thrown away - a numerical tally, mass, volume, energy content?

(5) Can the solid waste be easily sorted? How?

(6) What is the original function of the waste material?

(7) Is it really necessary?

(8) Can it be re-used for its original function?

(9) Can it be used for a new function?

(10) Do the materials have harmful characteristics? If so, what?

(11) What are the problems caused by the present method of disposal?

(12) How do other villages, cities, countries deal with the same problem?

(13) Who is responsible for dealing with the problem?

(14) What are the laws or regulations presently covering this activity?

(15) Why do people dispose of their solid waste in this way?

(16) How much does it cost to deal with solid waste disposed this way?

The questions as presented, and as suggested by a group, are in no particular order. This can be overcome to a reasonable extent, and a start made on gathering information by the next phase of identifying the sort of question being asked, and the probable source of the answer thus:

Question	Science or Social	Relates to Cause or Effect?	Likely Source of Answer: Literature,	Locality,	Expert
(1)	science	cause		✓	
(2)	science	-	✓	✓	
(3)	science	cause		✓	
(4)	science	-	✓	✓	✓
(5)	science	effect	✓		✓
(6)	social	cause			
(7)	social	cause	(inappropriate)		
(8)	social	effect			✓
(9)	social	effect	✓		✓
(10)	science/social	effect	✓		✓
(11)	social	effect	✓		✓
(12)	social	-	✓		✓
(13)	social	-	✓		✓
(14)	social	cause		✓	
(15)	social	-	✓		✓

In categorising the questions in this way, it will be found that some questions don't fit neatly, nor is there full agreement on the choices made. This does not matter greatly for individual questions because the process still serves to draw attention to the aspect of the total problem addressed by different questions, as well as get students to consider where (and how) they are going to get some of the answers.

As information is acquired about the problem it soon becomes necessary to summarise the situation as it has become known. This can be done in the following stages:

Social Causes:	the original function of the solid wastes material - the need for it,	(6) (7)
	why people dispose of it the way they do.	(14)
Science Causes:	what is being thrown away?	(1) (2) (3) (4)
Science Effect:	problems it creates	(10)
Social Effects:	problems it creates	(10)
	who has responsibility for dealing with the problem?	(12)
	what regulations are there?	(13)
	what does it presently cost?	(15)
Possible Solutions:	some methods of dealing with the problem	(5) (8) (9) (11)

Throughout the process of gathering information other questions will be raised, along with ideas for possible ways of dealing with the problem. Such information can naturally be incorporated into the final summary report as considered appropriate. What the structured summary as presented indicates is that surrounding the contribution of science to the cause or resolution of any environmental problem is a social context within which the basis of the problem arises and through which any change, whether science or social, must occur.

Stage 3

The following are a number of suggestions for dealing with the problem of soild waste disposal:

(1) change the person/authority responsible for dealing with the problem.

(2) introduce or change the legislation.

(3) introduce a depoist scheme on items (e.g. bottles, cans) that can be easily re-used for the same original function.

(4) develop a sorting-of-rubbish process at a dump site to facilitate re-use of resources.

(5) increase people's awareness of the problem and suggest some things that they could do, by producing an appropriate educational media package (e.g. slides + tape, film, display).

(6) promote different garbage collection procedures (e.g. villager/householder sort out rubbish prior to its collection).

(7) seek the withdrawal from manufacture of certain items (e.g. aluminium cans) and their associated packaging.

This list does not exhaust the possible ways of dealing with the problem. Suggestions made by students will relate to the particular problem and the local situation as well as the area of science they are presently dealing with.

Detailed consideration of two of the suggested solutions could produce the following:

(1) Problem: Solid Waste Disposal

Suggested Solution: introduce a deposit scheme on items that can be easily re-used for the same original function.

Consequences:

(1) ecological: ..decreases the rate of use of some resources
..change in energy consumption

(2) economic: ..initial cost increase in handling the items with a deposit; probably reflected in higher price for the product

(3) political: ..political party supporting the introduction/ increase of deposits challenged by another party not supporting the change

(4) aesthetic: ..reduction in litter,
..smaller volume of waste to be disposed

(5) scientific/ technological: ..machines needed to help handle the collection, cleaning and recycling of the items

(6) social: ..decreased demand for jobs in mining sector, more jobs in handling the recycled items, buyers of product have to pay more (at least initially)

(7) other: ..media publicity and involvement contributing to increased social awareness of environmental problems

(2) Problem: Solid Waste Disposal

Suggested Solution: develop a sorting-of-rubbish process at the dump site to facilitate re-use of resouces.

Consequences:

(1) ecological: ..decreases the rate of use of some resources
..change in energy consumption

(2) economic: ..cost of dumping rubbish might be increased

(3) political: ..support for the new project

(4) aesthetic: ..reduction in litter

(5) scientific/ technological:
..development of sorting processes
..design of new sorting machine
..creation of employment opportunity for scientist/engineer involved in waste disposal

(6) social:
..replacement of many unskilled workers by a few qualified technologists, or alternatively:
..increased employment for unskilled labour to sort rubbish.

(7) other:
..should some type of sorting machine be purchased from overseas there would be:
..change in balance of payments
..reduced opportunity for local unskilled employment
..higher costs to product users

Stage 4 Getting Involved

In the following Unit XII it is suggested that the students role play an open discussion of the problems and some of the suggested solutions.

Environmental problems of this kind generally include the following:

(1) individual (or group) demanding change.

(2) individual (or group) favouring one possible solution.

(3) individual (or group) favouring an alternative solution.

(4) individual (or group) who benefits from the existing situation to whom change implies effort, increased costs and/or decreased profits.

(5) group who is most likely to have to pay for any of the proposed changes.

(6) group responsible for regulating the problem.

For solid waste disposal the following groups would probably be represented at any public discussion:

industrial representatives (e.g. manufacturers of bottles, cans)

local council and its engineers

citizens

shop-keepers

local politicians

garbage collectors

students/action group promoting change

For classroom discussion it would be desirable to include a "scientist" or "engineer" who had studied the problem and who could contribute information and ideas on dealing with it practically.

It is not possible to provide particular details as to the content of such a role-play situation, but the following points would most likely need to be included at some stage, either during or in discussion afterwards:

(1) users of particular products will probably have to pay more either directly at the time of purchase, or indirectly through increased local taxes to reduce or eliminate the problem.

(2) while action may produce present tangible benefits, the main advantage of doing something now is to prevent a worse situation later.

(3) any one person may perceive both advantages and disadvantages in changing the present situation.

(4) all the facts, costs and benefits of the situation will never be known but discussion is still warranted to increase general awareness of the problem.

(5) it is possible to make a decision to do nothing.

(6) scientific information and skills can assist in but not completely eliminate an environmental problem.

(7) scientific communication skills can be used to detect faulty reasoning and to distinguish between logical and emotive argument.

The important feature of the role-play situation is the opportunity for students to express (and/or see expressed) a range of opinions and points of view with which they can identify. Such identification then enables students to decide where they stand in relation to the problem and the extent to which they want to get involved in resolving it.

Stage 5

The range of possible social actions that could be taken to assist in resolving the problem depends very much on the local situation in which it occurs. For solid waste disposal the following might be considered and found useful, or suggestive or more appropriate forms of action:

..write an article summarising the problem and the action that is necessary to deal with it, for the school magazine and/or use by the local media.

..prepare an illustrated display of the problem for use within the school and/or local community.

..organise a "collectathon" i.e. a day on which everyone is encouraged to search the town or countryside and collect the rubbish, which is then piled up at some central locality to highlight the problem.

..write to the appropriate authority (local council?) with suggestions, requesting that they take some action.

..prepare a working demonstration or model of how a collection of rubbish might be sorted.

..produce posters and car stickers with a series of suitable slogans:

"keep our countryside beautiful"

"waste not, want not: RECYCLE"

"save energy: RECYCLE"

Stage 6

Using this example the science teacher educator may wish, as a class exercise, to apply the criteria contained in Unit XIX to the suggestions given. Naturally, the ratings that would be given would depend very much on each local situation.

A SOCIAL ACTION CHALLENGE:

AN EDUCATIONAL AND ENVIRONMENTAL JUNCTION

When the pre-service teachers have worked through these six units they will have acquired some degree of the skills that are involved in environmental education. One way to evaluate these skills and their commitment as environmental educators is to challenge them to undertake the social action of mounting a public display that seeks to communicate with others in their institution or with the nearby public in their community. Because of its emphasis on communication, it is an evaluation of them as <u>teachers</u>. In other words they are to plan a "meeting" between them and others about an environmental issue. This is an example of a "junction" (see page 10).

The public display could deal with one or more of the four major aspects related to the problem-solving approach involved in environmental education. (The number of aspects covered will depend on the timing and opportunities that can be created in particular situations.)

The four major aspects are:

(1) presentation of the problem

(2) an outline of some of the possible courses of action and their respective implications

(3) a summary of the social action taken by the pre-service teachers

(4) an assessment of the effectiveness of such social action.

In deciding on the form of the junction, it is necessary for the science teacher educator in conjunction with the class to determine:

(1) the intended audience, e.g. the school population, the general public, government officials, private enterprise, or a combination of these.

(2) the venue, i.e. what could be the most suitable location for such a happening.

(3) the best time for reaching the intended audience.

(4) the best manner of presenting the various aspects.

Probably the simplest form of an extended junction would be one aimed at the rest of the students in the school or college, mounted in the main entrance way or in some classroom, on display for say a week, using a variety of presentation methods including photographs, static displays, models, and audio-visual techniques, with the pre-service teachers in attendance at specified times to answer question, present debates, etc.

Setting up a Function about Solid Waste Disposal

Solid waste disposal as an environmental problem, easily permits the holding of an education function at any time throughout the period during which it was being investigated.

Four possible "functions" to set up could be:

(1) having found out about the problem (Unit X) it would be possible to present

"the importance of the problem"

and "what the investigation has revealed so far"

to appropriate persons in the school and/or local community for comment.

(2) after work on suggesting possible solutions to the problem, these could be presented to appropriate scientific, social, economic, legal and possibly manufacturing experts for comments and suggestions.

(3) following the suggestion and selection of some forms of possible social action, they can be presented and explained to representatives of those in the community most likely to be involved for comments and suggestions.

(4) a presentation of all phases of the investigation, including an indication of what happened as a result of undertaking certain social actions, thus highlighting the extent to which society responds (or fails to respond) to environmental problems like this one.

Evaluation of the educational function could be done by a combination of assessments including:

(1) the standard of the various aspects of the display.

(2) the ability shown by the pre-service teachers in dealing with the visitors' questions.

(3) the comments from visitors themselves.

This latter aspect could be based on a fairly simple questionnaire to be filled in by persons who have observed or participated in the function. In a school this could be organised in classes after the event or in a public place just before leaving the display.

Typical questions might be:

(1) is there anything about the environmental problem presented to you that you don't understand, or consider correct?

(2) in resolving the problem did any possible alternatives not discussed so far occur to you?

CHAPTER 4

TEACHING STRATEGIES FOR USE IN ENVIRONMENTAL SCIENCE EDUCATION

Science teaching in the past has tended to be restricted to a relatively few pedagogical techniques, including teaching (teacher-centred) exposition, questioning, and laboratory confirmation with experiments of facts and theory already presented. The development of a scientifically literate person, as well as one who is actively concerned about the environment, requires a much greater number of techniques to be used.

The suggestions in this chapter fall into two categories. In Part A there are a number of suggestions for use inside the normal classroom. Part B on the other hand outlines teacher and learning experiences that are set outside the school and the classroom. Both sets of suggestions are intended to supplement the present approaches to teaching science not to negate them. Where they have been tried in a number of places, pupils' motivation for learning increases, and there is a greater achievement of an appreciation of science in its broader sense.

PART A

TECHNIQUES FOR CLASSROOM USE

Some of the techniques suggested take little or no time to incorporate into lesson preparation but others do require more effort and planning. This is justified because of the contribution such approaches make to the learning of science by both students and teachers. Indeed, without adopting and adapting some of them for use in science classrooms, it is very difficult to have much expectation that any significant advances will be achieved in science of new possible outcomes that are now recognised for science education.

A number of these pedagogical techniques are given in the columns that follow, together with suggestions for when they can be used and the advantages and disadvantages that are associated with each technique. Most of them find a place in one or other of the Units in this book and hence teachers can gain some familiarity with them.

STRATEGY DEFINED	OCCASIONS FOR USE	ADVANTAGES/DISADVANTAGES
Buzz Group This is a group activity involving a small number of pupils (2-8) and goes for a limited period of time e.g. 4-5 minutes, after which feed-back is given to the larger group in some way, generally by one member of the group.	It is used after some input has been made either orally by the teacher or in some other format, e.g. film, and requires the students to respond in some specific way as requested by the teacher to that input.	The advantage of this technique lies in involving more students in discussing a problem than if the class remains as one large group. If a buzz group leader is appointed it fosters leadership and the taking of responsibilit To be successful it must be used relativel frequently at first with pre-arranged groups otherwise a great deal of time can be lost getting organised.

STRATEGY DEFINED	OCCASIONS FOR USE	ADVANTAGES/DISADVANTAGES
Class Discussion This activity involves the whole class focussing its attention on a question and/or issue with each student being allowed to contribute informally, but in an orderly manner.	It is used to allow students to put their thoughts into spoken words and can be used by the teacher to (1) see if they understand what has been going on. (2) express opinions and ideas without having to formally write them down. (3) question the teacher and each other about the topic.	Class discussion can be useful in dispelling any misunderstandings on the part of students without them having to say so, through listening to others. It encourages the development of oral skills and confidence in public speaking, as well as the transfer of thoughts into words and the questioning of assumptions. Initial difficulty can occur in getting students started, but in time it can be an activity that continues for too long.
Group Discussion (i) with a teacher: Involves the whole class, with the teacher acting as supervisor or leader.	Its use depends on the ability of the teacher. Through conscious direction, it can be used to help, guide, moderate, and direct student thinking, as well as challenge assumptions and facilitate the exchange of ideas.	Ones use of this approach to teaching enables some students to avoid involveme Teachers must be conscious of the desired outcome to be achieved. Can result in the developing of more positiv relationships between teacher and studen
(ii) without a teacher: Can be the whole class or two or three large groups. Students frequently permit one of their peers to adopt the role of supervisor.	Can be used when ideas and uninhibited communication between students is being sought. Useful when controversial issues are being investigated.	Permits a sharing and communication of ideas between students and requires an agreed goal and time limit, otherwise discussion can become largely irrelevant
Brainstorming Another small group activity involving perhaps 5-10 students in which they are asked to give, without critical analysis, possible solutions to a problem. A time limit of say 10-15 minutes is imposed. All possibilities are recorded for subsequent use.	Is used as a formal device to encourage and stimulate thought in relation to a problem under investigation. Suggestions, no matter how unusual, from one person can serve to trigger off ideas and suggestions from another. The time is not to be used in evaluating suggestions but in producing them.	A useful technique is providing student input for the ongoing lesson and stimulating others. Difficulty arises in avoiding premature assessment or judgeme of any suggestions, and of obtaining original, useful ideas.
Committee Work Involves the active participation of groups of 4-8 members who become collectively responsible for the carrying out of a task, or requiring a problem.	Committee work can be used when a large number of separate tasks need to be done, and they can be apportioned to individual members. The class could be composed of several committees each focussing on either different aspects of the same problem or on entirely different problems.	Useful for allowing students to take on responsibilities over a period of time (2-5 weeks) and to practice organizing themselves, and reconciling different opinions. Activities need to be monitored so that the work involves everyone and not just the willing few.
Debate This requires two groups of students with 3 or 4 members in each group presenting ideas and arguments of opposite points of view to the rest of the class (or assembled group). A time limit of perhaps 3 minutes is allowed for each person with each group taking it in turns to speak.	A debate is a useful strategy when genuinely controversial issues are being discussed. It permits those with quite opposite views to express them and the reasons for holding them. As such it facilitates the exploration of values, as well as develop the notion of individual choice and responsibility.	Debates are most useful when genuine differences in attitude or proposal for action exists. Properly handled they permit the development of public speakir and the orderly presentation of facts an ideas. However, they require time for the preparation of the respective points of view. The topic chosen for debate must be of vital interest to those that participate as well as those that lister
Questionnaire This is the development of an orderly set of questions to be asked of a number of people that seeks information and/or their views on a particular topic. The answers recorded can then be analysed to give an indication to the extent of agreement or disagreement amongst those questioned on that topic. If a proper sample of people answer the questionnaire then the answers can be extrapolated to be a reflection of everyone's point of view.	A questionnaire is used to gain information and/or to sample people's opinions in relation to a survey or project being undertaken. As such it can help define the extent of a problem or public feeling towards a proposed course of action (real or imaginary).	It takes time and experience to produce an orderly set of questions that comprehensively covers the information being sought. The construction of a questionnaire however requires those that propose it to define early in their work what it is they are really seeking. Properly administered, a questionnaire produces excellent data from which conclusions and support for action can be drawn.

STRATEGY DEFINED	OCCASIONS FOR USE	ADVANTAGES/DISADVANTAGES
Media Imitation This strategy encourages students (singly or in groups) to produce their own versions of newspapers, radio and TV programmes and films.	Imitating the media is an excellent strategy by which students can get information of their choice, along with their views, to a wider group of people than those in the class. Depending on the circumstances and the issues being discussed, the products of such a strategy can be distributed throughout the schools, to parents, the local community or to the whole region.	To be effective, what is produced must be reasonably comparable in quality to the existing media, if it is to be circulated widely. It permits close involvement and team interaction along with the development of verbal, written and visual skills, as well as clarifying attitudes and values. Requires time, but can be an effective form of both learning and social action.
Reflection Can be regarded as the opposite to brainstorming, but likewise directed towards the production of suggestions or ideas. Entails giving students time to sit quietly (if not alone then undisturbed) and think about a specific problem that has been posed.	Used to encourage the development of creative ideas in response to a problem. Reflection time (of a set period perhaps 10-15 minutes) can be provided in the classroom as well as an undertaking to be done between class sessions at the convenience of the student.	Requires a prepared mind, one that has had access to a wealth of information as well as some practical experience. Cannot be evaluated directly, only by student reaction and the nature of the output from the process.

Two other possible teaching strategies are of such potential value to the science teacher that they are presented more fully, with examples and suggestions, in the next two units. Both of these are quite essential to the teaching of science for environmental education, and hence should be included in the programme of teacher education for any such science teachers. The first, the use of role playing via simulation games, is one of the best ways that have been developed to enable pupils in classrooms to share in something of the reality of issues in the real world beyond the walls of the school. The second, planning for the conduct of field study or an excursion involves teacher and pupils thinking carefully about all the aspects of moving their classes out of the classroom, and school into the reality situation they have chosen to study.

A third unit has been included dealing with the development of a local environment trail. Such a technique is often used in geography and social studies, but can be easily adapted for use in a scientific and/or environmental context.

Role Playing and Simulation Games

Children of most cultures play games. Through the use of imagination and fantasy children have been able to undertake a range of roles in the most unusual situations. This facility for involvement in novel circumstances by children (and adults) is now being used in education in exercises under the general headings of 'role playing' or 'simulation'. Although developed mainly for teaching in the area of the social sciences, simulation activities can be used to advantage by science teachers in promoting scientific literacy, as well as for environmental education.

In any simulation activity:

(1) participants take on roles which exist in their situation in the real world, and become involved in discussions and/or decisions in relation to that situation.

(2) participants experience simulated consequences as a result of their role-play and associated decisions.

(3) the results of the simulation are reflected upon and discussed, with particular attention being given to the relationship between the reasons for the decisions and their consequences.

Simulation activities come in three main forms: role-play, games, and computer simulation. The first of these is described and used in Unit XII while the use of computer simulation is omitted from this book because most science teachers still lack access to computers for use in their classrooms.

Gaming is generally more complex than role-playing because of its use of more formalised materials and procedures. An immense variety of games for use by science teachers has been produced, many of which, with modification, could be used under a range of circumstances. Also, a number of games have been produced relating to situations in the environment which, while specific to some societies, have such widespread occurrence that enterprising and creative science teachers can, without too much effort, modify them to relate to highly relevant local situations.

There is one important element to note here. Societies and cultures differ very widely about how their members are expected to participate in decisions about how life goes on. Perhaps the most subtle but important aspect of developing or using simulation in classrooms is maintaining contact with what is possible and hence real in the situations being studied. Just as in Units XII and XIV, great care must be taken to choose learning experiences of social actions that are possible and acceptable in your society.

An example of a game is produced in the following unit and is loosely based on The Conservation Game by David Lewis and T. McB Carson, suitably modified for possible use in developing countries.

UNIT XV

THE AIRPORT LOCATION GAME - A SIMULATION

INTRODUCTION

The game aims to illustrate the complexity of considerations involved in choosing the site for a new airport. This situation is one that applies in most countries. As such, it demonstrates the nature of environmental problems and the factors that are involved in decision-making when issues of conservation, resource use and pollution are involved.

The students are asked to put themselves in the position of those who are concerned about the location of a new international airport. It is the responsibility of the science teacher educator to choose two or more possible local sites for comparison by participants as to their respective merits.

UNIT XV: THE AIRPORT LOCATION GAME - A SIMULATION

Objectives

(1) to assist students become aware of the complexity of environmental situations

(2) to help students to comprehend social attitudes

(3) to develop skills of communicating how various factors relate to decision-making

Environmental Education Aims

- to help students acquire an awareness of and sensitivity to the total environment
- to help students acquire social values and strong feelings of concern for the environment
- to help students identify alternative approaches and make informed decisions about the environment that recognize ecological, political, economic, social and aesthetic factors

Science Process Skills

measuring, matching, communicating

Pedagogical Techniques

role playing, gaming, discussion, debating

Preservice Teacher Needs

(1) to gain experience of the technique of role playing

(2) to gain confidence that games are enjoyable and provide useful learning

(3) to recognize the organization and structure that is needed in the use of simulation in the classroom

Resources

1. map of region (1:100000 if possible) within which airport is to be sited with markings to show (i) built up areas, (ii) agricultural land and (iii) areas to be conserved (e.g. national parks, historic buildings etc.)
2. an acetate transparency of a possible layout of an airport (to scale)
3. work sheets with details of costs and conservation points
4. role play brief plus additional relevant information and maps

Suggested Time

About 4-6 hours distributed so that some group preparation can occur

SUGGESTED APPROACH

Groups of between 15 and 20 student teachers can operate as a "Commission", with the science teacher educator acting as chairperson if required. Roles can be allocated as follows:

A: assessors and accountants

(these are civil engineers and accountants who are responsible to the Chariman of the "Commission" to check the site chosen by the public service engineers and the estimate of costs associated with its development.)

B: public service engineers

(these are planners who select a possible site for the airport, and design the associated facilities for airport personnel and travellers, as well as the access roads, and services for electricity, water and sewage disposal.)

C: local community representatives

(these are representatives of agricultural/farming interests and townspeople, who are likely to be affected by the choice of site, and the noise associated with aircraft movements.)

D: conservationists

(these are people concerned to preserve the natural environment, and historians/archaeologists concerned to preserve local items of man's heritage.)

The Chairperson describes role-briefs, preferably in advance, so there may be some preliminary reading.

The group is told that the purpose of the game is to present differing points of view. The object of the environmental situation (and hence the game) is, however, to locate an international airport somewhere on the map, along with (1) a town (or an extension of existing towns) to cover 30 square kilometres with satisfactory road links to the airport; (2) road connections from the airport to the major town/city shown on the map; and (3) provision for water, electricity and sewage disposal facilities for the new town and airport.

The site must be chosen to be as economical as possible, <u>and</u> with the minimum loss of conservation points. Costs are incurred and conservation points are lost for any square kilometre that is required for the airport complex and associated facilities. (An example of this is given in the worksheets, but can be modified by the science teacher educator according to local conditions.)

When each student is familiar with his/her briefing document, the game begins.

Step 1

The public service engineers select a site and present the case for it to the Chairperson and his/her assessors and accountants.

They check the site and commence their own preliminary calculations as to cost of purchasing that site. While the assessors and accountants are doing that, the local community representatives and conservationists consider the environmental effects, develop and present their counter-arguments, suggesting if necessary an alternative site. The monetary costs and the conservation points involved in such alternatives are again checked by the assessors and accountants.

Step 2

Once a possible site is identified and tentatively accepted, the public service planners determine the location of the required town and services. The Chairperson hears the ordered presentation of their case and the replies of others to them, while assessors check the cost sheets and conservation points for accuracy.

Step 3

By a discussion conducted by the Chairperson, an attempt is made to reach agreement by all on the best site; alternatively, the Chairperson and his/her assessors and accountants may come to a majority verdict amongst themselves.

Step 4

If more than one group is playing the game at the same time, there can be a presentation of each group's chosen site, along with their assessment, and a comparison then made.

(Costs used in the game can be made realistic by the science teacher educator assigning appropriate values for his/her own country and particular location. The assessment of conservation points is necessarily subjective. This in itself can promote discussion and the realisation of difficulty in decision-making when two incompatible scales are involved. However, some groups may choose to build the airport cheaply while others may see conservation as an important issue and be prepared to choose an airport location that is considerably more expensive.)

What follows is an example of the sort of worksheets that could be used in relation to this sort of simulation game. Because of the variety of circumstances under which this game may be tried, it is the responsibility of the science teacher educator to review these suggestions, and produce his/her own worksheets to illustrate the local situation.

STUDENT WORKSHEET 1

INTRODUCTION

General Information

The purpose of the Airport Location game is to present differing points of view about the choices that could be made in choosing the site for an airport. The object of the game is to locate a new airport and its related facilities (which includes a town covering 25 square kilometres, roads, water, electricity and sewage disposal facilities) with proper consideration of possible impact on agriculture, noise levels and conservation.

1. The use of agricultural land for the Airport can disrupt a whole way of life, as well as reduce the amount of food produced locally and for the wider society. This, in turn, would increase the cost of food that now has to be available from other sources.

2. Noise levels associated with the operation of an international airport can be such that considerably more land than that required for runways and terminals has to be purchased and alienated from its existing purposes and a number of possible new uses such as housing, etc.

3. Conservation items come in two major groups: those associated with the natural environment and those associated with man's history. Frequently some of these items are unique in that once despoiled they are irreplaceable, and considerations of this kind need to be taken into account during decision-making. Such items are given high conservation value.

You have been allocated a role to play. Relevant data are provided in a role-brief to support that role. However, as in all decision-making you are requested to use your own imagination and any other arguments you can invent using local facts and ideas wherever possible.

DETAILS OF COSTS, ETC.

(1) Buying land for airport, town, services, etc.

- (a) agricultural land - $ per square kilometre
- (b) built-up area - $ per square kilometre
- (c) conservation areas:
  - (a) natural areas - $ per square kilometre
  - (b) historic buildings, etc. - $ per square kilometre

(2) Construction of town and airport on 30 square kilometres

initial cost - $

if high-rise buildings involved, cost would be an extra $ for each square kilometre with this form of construction.

road links to airport from major city - $ per kilometre

(3) Provision of electricity

for main line - $ per kilometre

for branch line - $ per kilometre

(4) Provision of water

construction of pipe-line - $ per kilometre

excess charge for passing through an existing built-up area - $ per kilometre

(5) Provision for sewage disposal

construction of pipe-line - $ per kilometre

excess charge for passing through existing built-up area - $ per kilometre

(6) Compensation to farmers within the noise level zone of

45 decibels from airport - $ per square kilometre

for roads passing through - $ per square kilometre

for land crossed by electricity, water pipes or sewage pipes - $ per kilometre

TABLE OF CONSERVATION POINTS

	Points per square kilomotre
Loss of land for construction of airport and associated facilities:	
(a) agricultural land	2
(b) built-up land	10
(c) conservation areas	
(i) natural	1000
(ii) historic buildings, etc.	750
Loss of amenity by noise (i.e. in the 45 decibel or higher case), pylons, pipes, etc.	
(a) agricultural land	2
(b) built-up land	10
(c) conservation areas	
(i) natural	20
(ii) historic buildings	40

TABLE OF COSTS FOR LAND AND CONSERVATION

Type of Area	No. of sq.kms.	Cost per km^{2*}	Cost*	Conservation Points
(a) agricultural				
(b) built-up				
(c) conservation				
(i) natural				
(ii) historic				

Sum of land costs and conservation

Construction of town and airport

Total cost

STUDENT WORKSHEET 2

ROLE-BRIEFS

Assessors and Accountants

Your role is to check the site (or sites) selected by the public service engineers, both in relation to cost (financial and conservation) and reasonableness. As you represent engineers, it would be possible/desirable to disagree with the selection of the actual location, and within your responsibility to suggest better alternatives. This could be argued for on consideration of costs, suitability for the purpose, and desirability from the point of view of the community and/or environment.

Public Service Engineers

Your role is to select a suitable site for an airport in the given region. This is based on consideration of the needs of an airport and its associated facilities. Geographical constraints such as topography, access to power and water, distribution of built-up areas, agricultural land and land for conservation are all to be considered along with costs which are expected to be minimised where possible.

Local Community Representatives

Your role is to support or oppose any particular selected site for an airport. This could be for such reasons as community well-being, improved or loss of employment, environmental cost, noise pollution, conservation values, etc. The particular points to be used will depend on each community and the precise location of the proposed airport and its facilities.

Conservationists

Your role is to ensure that all conservation areas (natural and historic) are adequately protected from noise, pollution, and destruction. It will be necessary to prepare and possibly present arguments as to why any conservation area should be retained. To make your presentation more realistic it will be useful to know the location of various reserves and cultural features, as well as some of the factors which could adversely affect them.

PART B

TECHNIQUES FOR USE BEYOND THE CLASSROOM

The conduct of a field trip

Field activities are frequently encouraged in national parks, which make use of check lists along a nature trail. Such an activity is a form of environmental learning in that it seeks to sensitise people to particular features. It is useful as an introduction but it is only a beginning to the learning that could occur. In seeking "to provide students with opportunities to be actively involved at all levels in working towards the resolution of environmental problems" environmental education does need to make use of well-conducted field trips that involve learning beyond this introductory level. Accordingly, it is essential that students become active participants in any undertaking of this kind.

Location and purpose of field trips

Field trips can be conducted effectively in urban and large metropolitan areas as well as in rural villages and the natural countryside. Indeed many extremely valuable field trips for science and other subjects, can be conducted in the environments that are near the classroom. Depending on the purpose of the learning activity, the school or college grounds, the buildings themselves and the people who make up the school community can all provide suitable subjects for study in the sense that a field trip embodies.

Field trips may be planned for a variety of purposes, including:

(1) the collection of information for subsequent use in the classroom or laboratory.

(2) the illustration of scientific principles or problems that have been dealt with in classroom or laboratory.

(3) the opportunity to practise process skills using the local situation.

(4) the first hand observation and study of an environmental problem.

(5) the application of concepts and the experience of values by exploring a form of social action in a real situation.

The value of field trips arises from students learning best through first hand experiences. A well-conducted field trip is good for motivating students (and teachers) and for involving them in decision-making and organising an amount of data. For the science teacher, the community beyond the school provides a wealth of resources which are based on the application of scientific knowledge and which can only be talked and read about in the classroom.

In planning field trips, science teachers who see relationships between science and other subjects might well enlist the co-operation and participation of other teachers, as well as that of persons in the situation being visited.

Planning the field trip

The first step in undertaking a field trip is to carefully define its purpose. Apart from the general aims associated with the teaching of science and environmental education it is necessary to identify the questions for which answers are being sought by the field trip. As these are defined so too can the relevant processes and skills that are to be utilised.

Having decided on why and where a field trip is to be conducted it is necessary for the teacher to include in his/her preparation a visit to the area or site before the students do. Such an undertaking is to provide the experience necessary for dealing with the five aspects of any field trip.

(1) preparation before departure, (2) the outward journey,
(3) activities at the destination, (4) the return journey and
(5) follow-up work arising from the outing.

(1) Preparation before departure

To make the most of a field trip it is essential to have the students well prepared and involved as much as possible in its planning. The nature and extent of student involvement depends on the purpose of the field trip, but could involve: collection/preparation of maps, study of aerial photographs, construction of questionnaires or interview questions, obtaining or making any necessary equipment, and practising the skills of using it, and reading relevant reports. The following table is a checklist that could be used prior to departure:

TABLE 4.1 A CHECK LIST IN PLANNING A FIELD TRIP

1	How is the trip relevant?
2	Questions to be answered by the field trip experience
3	Has permission to visit the site been given by the 'owner(s)'?
4	Form of transport required
5	Probable costs involved
6	Probable hazards/difficulties
7	Facilities available (e.g. toilets, water, food)
8	Equipment required
9	Length of trip
10	Number of people going (adult:student ratio)

In addition to anticipating problems and taking a first aid kit, it is necessary to check any legal obligations regarding excursions and to seek school as well as parental permission.

(2) Outward and (4) return journeys

Regardless of the length of time involved in moving between the school and the desired destination this journey can be made into a meaningful (and enjoyable) learning experience. This can be done by providing a checklist of things for students to look for, questions to answer from observations that can be made on the way, the making of a map of the journey, or the use of frequent short stops to study particular features along the route.

(3) Activities at the destination

Basic to all outdoor activities are maps, either official or drawn by students, on which the location of objects of interest have been (or are to be) marked.

A list of some possible field activities that might be undertaken in relation to science and/or environmental education is given in Table 4.2. This indicates the vast range of learning that is possible on such a trip, but the particular activities chosen will depend on the location.

TABLE 4.2 SOME POSSIBLE ACTIVITIES FOR FIELD TRIPS IN RELATION TO SCIENCE OR ENVIRONMENTAL EDUCATION

Science Activities	Environmental Activities
A Physical/technological measure climatic factors study local geological features analyse soil, photograph soil profiles search for fossils visit a quarry measure water salinity compare water samples along the length of a river analyse the operation of factory machinery observe industrial chemical processes list and identify building materials and their structural and other functions B Biological map (qualitatively and quantitatively) different vegetation types observe birds and plot distributions compare fauna/flora in a national park with those in adjacent areas	visit industrial sites and observe their environmental impact trace waste disposal routes for a town or village and compare with a city study energy production and distribution in an area visit a cemetry and identify population patterns visit a local market and construct food distribution maps (and prices) survey water usage and pollution trace the course and use of building materials work with a community on an environmental problem

(5) Follow-up

A field study that arises from and is properly integrated with classroom activities will provide a great deal of information which will have to be collated, analysed and evaluated. As such it provides the input for any number of lessons following the trip, all of which should be directed to answering the questions posed earlier. The students can then inform others in the school/community about their findings, by means of a junction event or by written reports which can also be used as a form of evaluation by the teacher if this is needed.

UNIT XVI

PLANNING A FIELD TRIP

INTRODUCTION

Any field trip requires careful planning if it is to lead to effective learning. Because the normal constraints of the classroom do not apply, it is even more important than usual that a teacher is very well prepared before the trip begins. Any materials that are needed must be clear and easily used by pupils in the field situation. All formalities of a legal and logistical nature must have been doubly checked. Thought needs to be given to how communication will occur during the trip as people tend to become rather spread out. The pupils will have to be taught previously any skills they will need to use in the field and many other points will need to be in a plan. This unit provided practice in making such a plan.

UNIT XVI: PLANNING FOR A FIELD TRIP	
Objectives (1) to develop students' understanding of the nature and function of field trips (2) to assist students in learning how to prepare and plan for the conduct of a field trip (3) to enable students to appreciate the significance of field trips in environmental education	**Environmental Education Aims** . to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems . to help students acquire the motivation for actively participating in environmental improvement and protection
Science Process Skills communicating, interpreting, inferring	**Pedagogical Techniques Suggested** (i) direct instruction (ii) class and small group discussion (iii) committee work
Preservice Teacher Needs (1) to feel confident in undertaking and planning a field trip (2) to feel that they understand an important technique in promoting environmental education through their science teaching	
Resources copies of "The Conduct of Field Trips" aerial photographs or maps copies of "Outdoor Study Code"	**Suggested Time** 1 hour minimum - up to 2 hours (excluding travelling time) depending on the activities selected for the unit

SUGGESTED APPROACH

Step 1

Prior to commencement of this unit the science teacher educator should give the pre-service teachers a copy of "The Conduct of Field Trips" to read. At the beginning of the first session, they could then be asked such questions:

- Can you suggest any additions or changes to the checklist,
- What are the legal requirements for the conduct of field trips that involve school pupils?
- What is a desirable and possible adult to student ratio?
- How can it be achieved?

Step 2

Divide the class into small groups (of about 6-8), give each a detailed map or aerial photograph, and ask them to produce a list of the possible purposes for which a field trip could be conducted at that location.

Step 3

After a number of possible purposes have been identified the science teacher educator asks each group to select one such purpose for further work. The group is then asked to propose and record a number of questions for pupils to answer that could be associated with the chosen purpose. (If time permits, the possible skills and processes required to answer the questions can also be identified: see Step 6(A).)

Step 4

When the members of the small group have agreed on a possible purpose for a field trip to the area and the sorts of questions associated with it, they are now asked, individually, to complete as far as possible the checklist contained in "The Conduct of a Field Trip" (Items 3 and 10 for example, could be omitted).

Step 5

The pre-service teachers are then asked to compare their answers to the checklist questions with those of the others in the small groups who have been working on the same purpose. Any differences can be discussed.

Step 6

A: (if more than 30 minutes is available)

Each small group is made into a committee having responsibility for preparing activities and worksheets for use on the field trip. They are to identify what is required and then use their own ideas to produce an outline of activities that could be done, while the pupils travel to and from the locality of the site and while they are on the site itself. The ideas generated by the committee can then be shared with other "committees" in the class which have been responsible for field trips to other localities in the area, and for other purposes.

B: (if less than 30 minutes is available)

The pre-service teachers are given a copy of the following exemplary 'Outdoor Study Code Principles'. After reading it they are asked to discuss the reasons underlying the principles and suggest

modifications and additions to the list

or to prepare a specific code from the list of principles for use

with school children in relation to a field trip to

(1) a national park

(2) a factory or industrial site

(3) an historic monument

and how they could be achieved in practice.

EXEMPLARY OUTDOOR STUDY CODE PRINCIPLES

Field trips by groups of students are always a potential hazard to the environment being visited. For example national parks or historic monuments are so designated because there is an interest to preserve these parts of the environment for future generations. This presents more difficulties to science than to geography, because scientific investigation frequently requires samples to be taken for further study and analysis. Such difficulties can be considerably reduced by teachers making students aware of the need for an Outdoor Study Code. By discussion with them as part of their preparation for the field trip, the principles of such a code can be used to establish what is appropriate behaviour for the particular location being visited.

The following list of principles for both teachers and students can be the basis for the formulation of an Outdoor Study Code.

(1) Because damage can result to plants, animals and soil in some environments through trampling and noise, field activities are to be designed so that the smallest area is affected over the shortest possible time.

(2) Because teachers and students are visitors to a locality when on a field trip, it is usually necessary to obtain permission for access to certain places, and to generally follow established routes within the locality.

(3) Because some field measurements require a degree of interference with the environment, e.g. digging for soil profiles, collecting geological and botanical specimens, etc., the least harmful and most economical methods are to be used.

(4) Because other people may also wish to visit the location (or the same class to return on another occasion) it is necessary not to litter or pollute, or to leave fires unattended.

(5) Because the people encountered at the site are at home or at their work, they have other responsiblities in addition to assisting school field trips. It is courteous and more productive if students are well-prepared and organised in asking their basic quesitons so that an effective but breif contact is all that is needed to gain the information required.

Local Environment Trails as a Pedagogical Technique

One of the basic principles of learning is that the more senses that are involved, the more meaningful will be the learning experience. Science teachers are fortunate in being able to make use of many of the senses in the laboratory setting and through classroom demonstrations. At present, however, only a few of them extend this principle readily to learning outside the classroom. The local environment just beyond the classroom can provide a rich and varied setting for students and in some ways it is at least as readily available as a school laboratory. In some situations where laboratories are inadequate the local environment can be an excellent substitute for these sensory and hands-on experiences that are so important for learning science.

The local environment for school students can vary from being a relatively isolated small school situated in a rural area some distance from a village, to a large school in a rapidly growing urban area. However, despite apparent limitations, all local environments can be utilised to reinforce science and environmental learning.

One way in which pupils and teachers can get to know their local environment more intimately is through the development of a local environment trail. Once established, a local environment trail can be used over and over again with a number of variations to achieve different but related outcomes.

What follows is an outline of the local environment trail concept, and a procedure by which it can be initially established. With experience, and with the same or different pupils, it can be revised and modified to draw attention to the inevitable on-going changes that occur in a local environment.

Characteristics and Purpose of a Local Environment Trail

A local environment trail is a planned route through a number of different landscapes which can be walked (or perhaps cycled) by anyone who is interested. It forms the basis for experiencing the local environment and seeks to influence people's perception of their environment by directing their senses to specifically chosen sites and sights.

The development of a trail will reflect the interests of those involved in its preparation, and could therefore have an historical, social or scientific bias.

From the point of view of a science teacher educator seeking to develop a commitment to environmental education by his/her pre-service science teachers there are at least four relevant environmental aspects which can be enhanced using a local environment trail. They are:

(i) awareness of the changes brought about by progress and development on the natural environment

(ii) recognition of the interrelations between village or urban living and the natural environment.

(iii) a knowledge of how the changes are brought about and what alternatives were possible

(iv) a willingness to be involved in the development or conservation of this local area

A local environment trail is more than an introduction to the present living and working places of the local inhabitants. It is distinguished from other sorts of trails by serving as a starting point for considering the changes that have occurred and what factors have given rise to the present situation. Ideally therefore it includes a visit to a part of the local area that is still in a relatively natural state, as well as various parts of the developed village, town or urban complex. If no relatively natural areas remain in reasonably close proximity to people's present living environment then photos, paintings, models, or other illustrations that may exist in a museum, or in the school or in the homes of local people can be used instead. Older people in the local community can also be a valuable recource for finding out what prior stages of the local environment were like.

In addition to being a route to follow, a local environment trail needs to be developed so that it includes ideas and information relating to people and their impact on the natural environment. This can be done through the preparation of a small booklet or pamphlet which has a map and relevant information and a set of questions to stimulate the pupils to these issues. The prepared text of such a booklet should both guide the trail users and help them to understand what is presently happening to this environment and by whom it is being regulated (if at all).

Schooling, because of the nature of so much of its learning, can develop in pupils an attitude of disdain or at least isolation from and ignorance of their local environment and their own interaction with it. Such things as their sources of energy, the production of their food, the availability of resources for local industries and the handling and disposal of local waste materials are essentials for any community of people. To many pupils and their teachers the details of these commodities are submerged under the mass of generalised knowledge that school curricula emphasise. The recognition of the interconnections between village or urban living and the natural and local environment can begin to happen in schooling when a properly constructed local environment trail can be used by teachers and their pupils.

In developing an active involvement in matters relating to the environment a pupil must first of all have a sense of familiarity with the setting, both physical and social in which he/she is to act. If this can be coupled with personal experiences of change, or evidence of possible effects of change, then a good formal preparation for involvement has been achieved.

The educational value of using a trail for learning is different from the educational value in developing such a trail. What follows in Unit XVII are suggestions for developing a trail. This experience can then be extended by pre-service teachers into either making trails for their own students or working with senior students to make a trail for others. These experiences will need to be complemented by enabling the pre-service teachers to be users (learners) of an already established environment trail. Being learners themselves on such a trail will enable them better to appreciate how their own pupils will react to this type of outdoor learning experience.

UNIT XVII

PLANNING A LOCAL ENVIRONMENT TRAIL

INTRODUCTION

As in planning a field trip, the first step in planning a local environmental trail is to carefully define its purpose. Depending on the age, experience and interest of the pupils this could be any one or more of the following:

(i) to arouse interest in the local environment

(ii) to discover the changes brought about by the development and modern technology on the natural environment

(iii) to discover some of the interrelationships between urban living and the natural environment

(iv) to encourage a critical evaluation of the impact of the present lifestyle of people and the environment

(v) to become aware of recent or impending changes

(vi) to prepare for involvement in an environmental problem

Once the purpose of the local environment trail is determined, it is necessary for its designers to have certain guidelines within which the task is to be undertaken. These should include (a) the area or extent of the local environment within which the ultimate users can be expected to travel, (b) a list of known locations of interest, (c) the available resources (maps, booklets, old photographs, etc.) that may be useful, and (d) a list of the sorts of questions that have been good learning stimuli for other trails (see below).

For this Unit, it is suggested that the science teacher educator think in terms of resource use and management as the learning purposes for the trail. Such an approach does not exhaust the possibilities of this learning technique but serves to introduce it. More importantly, resource use and management do relate directly to the six environmental concepts that have been given particular emphasis in this book (see Appendix 1).

The choice of the particular resources to be studied on the trail can be made by the science teacher educator, or by the pre-service science teacher after an initial visit to the local environment.

UNIT XVII: PLANNING A LOCAL ENVIRONMENT TRAIL

Objectives

(1) to increase student familiarity with the local environment
(2) to develop students' understanding of the dependence of present lifestyle on the natural environment
(3) to prepare students to become actively involved in environmental problems
(4) to enable students to appreciate the contribution of a local environment trail to environmental education

Science Process Skills

observing, measuring, questioning, classifying, communicating, interpreting data, inferring, hypothesising

. Environmental Education Aims

- to help students acquire an awareness and sensitivity to the total environment
- to help students develop a basic understanding of the total environment and the inter-relationship of man and the environment
- to help students develop the skills necessary for investigating the total environment and for identifying and solving environmental problems
- to help students acquire social values and strong feelings of concern for the environment
- to help students acquire the motivation for actively participating in environmental improvement and protection
- to provide students with opportunities to be actively involved at all levels in working towards the resolution of environmental problems

Pedagogical Techniques Suggested

(i) class discussion, group discussion

Pre-service Teacher Needs

(1) to feel confident in using the outdoors for science teaching
(2) to understand the interrelations between the natural environment and daily activities
(3) to feel that they understand an interesting technique in promoting environmental education through their science teaching

Resources

List of Suggested Questions
Maps of the local area for student use
Large map of local area for class use
Texts and references for background information
Printing/copying facilities to make a trail guide

Suggested Time (does not include time for field trips)

phase 1 : 1 hour +

phase 2 : 1 hour

phase 3 : up to 2 hours + student work time

STUDENT WORKSHEET

SUGGESTED QUESTIONS ABOUT A LOCALITY AND RESOURCE USE

(a) What did this locality look like 10, 100, 1000 years ago?

(b) What was the source of the chosen resource then and now?

(c) (i) How is the chosen resource transported/treated between its present source and our use of it?

(ii) Where does this happen?

(d) (i) What happens to the resource after we have made use of it?

(ii) Where does this happen?

(e) Where does the energy come from to enable this to happen?

(f) (i) Who is involved in the management of the resource?

(ii) Where do they carry out their administration?

(g) (i) What impacts does this use of the resource have on the local natural environment?

(ii) Where is this most obvious?

(h) Where are there any examples of using the resource in a way that does less damage to the environment?

SUGGESTED APPROACH

Phase 1: Getting Started

Step 1

The science teacher educator explains to the class that the local environment in which they live was not always like it is now. Over the years it has been changed in ways that are the result of people's interaction with what was originally a more natural environment. This can be illustrated by reference to the past and present practices for the use and management of a particular chosen resource(s). A preliminary visit to the area would be a distinct advantage, and a detailed map is essential.

Step 2

Either the science teacher educator announces the resource(s) that will be the focal purpose of the trail,

or

the pre-service teachers should choose a resource(s) which they would like to trace with a local environment trail.

Step 3

Either let the pre-service teachers suggest questions pupils would be able to answer by visiting various locations, and then compare these with the set of "Suggested Questions" on the Worksheet,

or

give each member of the class a copy of the Worksheet of "Suggested Questions" (as modified by the science teacher educator) for discussion and clarification.

Step 4

Divide the class into groups of three and arrange for each group to visit one or more particular places in the local environment (as marked on the map). At a convenient time, the small groups are to explore these parts of the local environment, seeking to answer their list of questions.

Phase 2: Designing the Trail

Step 5

On their return, each group is to locate on a large class map the particular locations (and any alternatives) which illustrate well the answer(s) to their question(s). (Other relevant places discovered on their visit should also be listed.)

Step 6

Using the map, the class is to devise a relatively simple route which links the locations in a sensible order. This could be done with the class divided into two or three clusters - with each cluster having to justify its route and the order of places to visit to the others until consensus is reached.

Phase 3: Presenting the Trail

Step 7

When the route is decided, the class (or the clusters in Step 6) are to prepare a possible pamphlet or leaflet (with map, relevant information, and questions) as a learning guide for pupils and other trail-users.

Step 8

At a convenient time, the class in small groups should follow the trail using one of the prepared leaflets. On their return, they should be asked to suggest changes in (i) places to visit, (ii) order in which to visit places and (iii) the prepared leaflet.

Step 9 (Social action)

Members of the class should attempt (a) to distribute the trail guide and map to other teachers (and similar people) in the community, and (b) to persuade them to use the environment trail as part of their pedagogy.

CHAPTER 5

EVALUATION OF ENVIRONMENTAL EDUCATION

INTRODUCTION

By now it will be clear that science teachers can, through their teaching, contribute to environmental education. They do so when they give appropriate parts of their regular teaching a certain orientation, the characterisitcs of which were elaborated in Units III, IV and V.

Since these characteristics differ quite basically in a number of ways from the teaching and learning intentions we associate with most of the secondary curriculum, it is not surprising that the evaluation of this type of education will also involve a number of procedures that differ from those that have been used in say traditional science education.

Traditionally, the emphasis in evaluation at the secondary level has been on the achievement by students of certain cognitive objectives. This has often been largely the recall of factual information, of conceptual definitions and the ability to do comparatively simple applications of quantitative relations or rules. In a few subjects of which science is one there has also been some expectation that certain practical skills of a psychomotor type will be acquired. These are evaluated either generally by a record of the students' participation in laboratory exercises or by a practical examination. There has been little or no emphasis in many secondary science courses on the acquisition of attitudinal or other affective outcomes of learning.

Since 1970 however, a number of secondary science courses have begun to emphasise the Science and Society, and other dimensions discussed in Chapter 2. There are, thus, a number of examples where learning of this type has been part of the regular examination of the subject and in this way evaluative information about the teaching is available. Some of these sorts of evaluation are considered in the first unit of this chapter because they do form a useful bridge to the evaluation that is needed for environmental science education.

UNIT XVIII

ASSESSING SOCIETAL ASPECTS OF SCIENCE LEARNING

INTRODUCTION

It has been one thing to develop a rationale for the dimension Science and Society as part of the curriculum of school science education. It has been quite another thing to find ways to fully include it in the teaching and learning of the classroom. Some of these have required science teachers to add to their repertoire of teaching techniques that are more familier to teachers of the social sciences or of the humanities. A number of these have already been emphasised in various units of this module and science teachers will be reminded of them again in the final section of this chapter.

One of the more difficult aspects has been the inclusion of suitable questions in the testing or the formal evaluation of students' learning. Examinations or tests in science education have traditionally included certain sorts of questions only and in many countries the so-called objective items involving multiple choice answers have been very popular and useful. There has also been a not surprising reluctance to include in written science examinations questions which might appear on a social studies or geography examination, and which have no specifically science content.

Nevertheless a number of ways have been devised by enterprising teachers to test the Science and Society dimension they are including in their curriculum. Where formal examinations are an important and regular part of the course of study, it is important to test each aspect of learning that is important. If this is not done, the learners soon treat untested aspects as unimportant.

Several of the examination boards conducting national or regional testing of courses in school science education now regularly include items of the type being considered.

In this unit some of these items will be used to further the acquaintance of pre-service science teachers with the dimension and to provide them with examples against which they can compare their own experience of the evaluation of students' learning in science:

UNIT XVIII-ASSESSING SOCIETAL ASPECTS OF SCIENCE LEARNING

Objectives

(1) to develop students' appreciation of the Science and Society dimension.

(2) to enable students to see that science and societal content can both be tested.

(3) to assist students to develop their own skill in item design.

Environmental Education Aims

to help students identify alternative approaches and make informed decisions

. to provide students with opportunities to be actively involved

Science Process Skills

analysis, communicating

Pedagogical Techniques

(i) small group work
(ii) paired argument
(iii) individual task

Preservice Teacher Needs

(1) to become aware of means of testing Science and Society learning

(2) to feel more confident in designing test items

Resources

Worksheet 1 & 2

Recent science examination papers

Suggested Time

Two hours

SUGGESTED APPROACH

Step 1

The science teacher educator provides the class with Worksheets 1 and 2. Its members are then asked to discuss in pairs the questions on Worksheet 1 in a manner that enables the Item Analysis on Worksheet 2 to be completed.

The science teacher educator may find it helpful to provide an exemplary analysis such as might be produced for Question 8.

Question	Basic science facts and concepts	Types of societal information required	Is science content essential in answer, and how is it ensured?
8	strength durability surface texture corrosion resist-ant	cost aesthetic appeal ease of working availability	Yes "should include reference to..."

Step 2

When the analysis of these questions is complete the pre-service teachers should be asked in their pairs to take it in turns to argue the two views, that these sorts of items should or should not be included in the assessment of science learning locally. The arguments for and against should then be collected from the pairs so that the range of points is evident to the whole class. The list should also note the sorts of constraints that exist locally against such teaching and testing of science at school.

Step 3

The science teacher educator should then give the pre-service science teachers a recent test or examination paper from one or other of the school science subjects. Its items should then be checked to see how many items test Science and Society learning. For two of the items that do not include either of these dimensions, each pre-service teacher should be encouraged to create new questions that use the same science content but now would also test this dimension of scientific literacy.

WORKSHEET 1

Answer THREE questions in this section. These questions are largely concerned with the applications of chemistry to society and, in your answers, reference should be made to the chemical principles involved wherever possible.

This page may be detached. Write your answers on the lined paper which follows this section.

1 (a) Explain the action of a soapy detergent and how this action is affected by hardness in water.

(b) Describe the advantages of the use of non-soapy detergents and explain how some problems associated with the earlier types have been overcome.

(16 marks)

2 (a) Explain the structural relationship between cellulose and simple carbohydrates, and give an account of the manufacture of a man-made fibre from a cellulosic material.

(b) Discuss the implications of the replacement of cellulose-derived materials, e.g. paper products, by plastics as packaging materials.

(16 marks)

3 (a) Discuss the ways in which rocks which consist essentially of calcium carbonate and products derived from them are of great importance to the building industry.

(b) Explain the causes of the erosion of limestone buildings and indicate how this erosion can be prevented.

(16 marks)

4 (a) Give an account of the rusting of iron, paying attention to the factors which affect it, and to the electrochemical processes which operate.

(b) Explain the chemical principles underlying the techniques used for the prevention of corrosion of iron structures.

(16 marks)

5 (a) Discuss the improvements in food production which have been made through the use of pesticides, herbicides and fertilizers. Include in your account references to the chemical structures of some of the substances you mention and to the manufacture of a fertilizer.

(b) Give an account of the environmental problems caused by the extensive use of fertilizers.

(16 marks)

(University of London, G.C.E.,
Chemistry in Society, 1980)

6 Noises (other than speech and music) play an important part in our lives, as signals, warnings and sources of information. On the other hand persistent loud noise is a hazard in the lives of many people.

(a) Discuss noises that have beneficial uses and describe the nature of these noises as sounds. Use two examples.

(b) Describe the effect of persistent loud noise on the hearer and indicate at least one way in which the effect could be reduced or avoided.

(6 marks)

(Victorian Institute of Secondary Education H.S.C. Physical Science, 1980)

7 A typical motor vehicle uses about 8 litres of petrol per 100 km travelled. The overall efficiency of the energy conversion is about 15 per cent, that is, only about 15 per cent of the energy released by burning the fuel is transferred to the wheels and used to overcome road and air friction.

(a) Calculate the petrol consumption under similar road conditions if the overall efficiency were increased to 60 per cent by an improved vehicule design.

(b) Briefly describe two current approaches to gaining more efficient use of fuels in transportation.

(5 marks)

(Victorain Institute of Secondary Education H.S.C. Physical Science, 1979)

8 Write an essay on the advantages and disadvantages of wood over other materials used for similar purposes. As least three (3) advantages and three (3) disadvantages should be given. Your discussion should include reference to the properties of the materials.

(12 marks)

9 A recent list of 10 outstanding world achievements in chemical engineering science included 6 that related to organic chemicals (or classes of chemicals) - synthetic antibiotics, plastics, petrochemicals, synthetic fibres, synthetic rubber, and high octane petrol.

Write brief notes about two (2) different useful organic chemicals (or classes of chemicals) you have studied, which clearly indicate (i) how the use relates to the structure and (ii) how uncontrolled use can lead to "abuse" or biological disadvantage.

10 An industrialist wishes to build a nuclear fuelled power generating plant. He is strongly opposed by a group who desire a coal fuelled plant. The proposed sites are environmentally suitable and cost is not relevant to either group.

Bearing in mind the different natures of the fuels and their waste products, develop at least three arguments the industrialist might use to support his application to build the nuclear plant.

(6 marks)

(Victorian Universities and Schools Examination Board H.S.C. Physical Science, 1977)

11 Ten years ago, it was often said that the amount of sulphuric acid consumed by a nation was a good measure of its social and technological development. Today we are much more inclined to simply say that sulphuric acid consumption measures technological development.

(a) In the space provided write brief notes on the chemical processes that produce sulphuric acid.

(b) In the space provided indicate two (2) uses of sulphuric acid that justify why it reflects the technological development of a country.

(c) In the space provided give at least two (2) reasons why social and technological development are not now seen as automatically related.

(d) In the space provided write a brief note about one (1) social problem arising from the sulphuric acid industry and describe how you might solve it.

You should spend not more than 25 minutes on this question.

12 A lake which supplies water to a large urban area had a severe algal bloom which passed through the filters into the water supply, causing complaints from consumers. One suggested cause of this bloom was:

> Pesticides, arising from sheep dip residue some miles away, passed into a feeder stream of the lake. This either killed or prevented reproduction of certain water fleas. These had been grazing in the algae in question and their absence allowed the algae to grow without their normal limitation.

(a) Design an experiment to determine what concentrations of a given pesticide would kill 50 per cent of the water fleas. List the main items of apparatus you would need, and state how they would be used. What other factors might contribute to the mortality rate of the water fleas in the experiment? (The water fleas in question grow to about 2 mm in length.)

(b) Outline briefly how you would determine, in the laboratory, the population density of algae which would support a given density of water fleas. (The water fleas reproduce every three weeks or so, producing about 10 offspring.)

(c) With what degree of validity could the conclusions drawn from these laboratory experiments be applied to the real situation?

(20 marks)

(Associated Examination Board, U.K. G.C.E., (Integrated Science, 1974)

WORKSHEET 2

Item Analysis of Questions from Science Examination

Question	Basic science facts and concepts tested	Types of societal information required	Is science content essential in answer and how is this ensured?
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

UNIT XIX

EVALUATION OF ENVIRONMENTAL OBJECTIVES IN SCIENCE LEARNING

The strong priority for affective objectives in environmental teaching poses a major challenge in education evaluations. Traditional approaches via paper and pencil testing (written examinations) are much less easily used for these affective objectives. Attitude measurement is fraught with unresolved problems and is at its best a high inference measure. Furthermore, the type of environmental education this book encourages is quite different to science education with its rather universal cognitive content. Its affective and learning intentions will be highly specific to the situational and school context in which the education occurs. Much more intimate and direct "measures" of this learning need to be considered and applied. Even when these are used as suggested below, there will be other features of environmental learning that are not meaningfully tested by paper and pencil instruments. For level of concern and commitment to act, the science teacher will find that the best form of assessment of his/her students will come from the direct observation and experience of their responses in class and in the activities that form a major part of the pedagogy of environmental education.

Environmental education, if its objectives (see Chapter 1, Unit 3) are taken seriously, almost reverses the priorities for learning, because it does emphasise objectives to do with attitudes and values like concern for the environment and commitment to contribute to its improvement. It also adds a number of process objectives like the skills of *decision-making, recognising alternatives, participating in social action, communicating, and problem solving.*

William Stapp, former chief of the Unesco-UNEP International Programme, with a number of his co-workers at the University of Michigan has developed an approach to evaluating environmental learning using a profile of measures.*

They have recognised the objectives of environmental awareness and environmental knowledge as key ingredients in the formation of the sorts of attitudes that environmental education seeks to generate. Although these are not all that is involved in an attitude, they are important and measurable by more or less conventional processes.

As a third component of the profile, they recommend a measure of the learners' values about the particular environmental problem being considered in the teaching.

Finally, they use a measure of those process skills referred to above that have particular importance in the environmental problem.

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* W.B. Stapp, Dorothy A. Cox, Paul T. Zeph and Karen S. Zimbelman, "Evaluation of a Transportation Curriculum Module for High School Students". School of Natural Resources, The University of Michigan.

In one particular case of environmental teaching, the four measures were obtained from a 28-item test instrument that included the following sorts of questions:

(i) agree-disagree statements.

(ii) fill in the blank questions.

(iii) preference ranking.

(iv) hypothetical actions based on given problems.

(v) learner reaction to a series of slides depicting examples of the environmental issue.

In the second unit of this Chapter the pre-service science teacher will be given practice in developing such an instrument based on some of these sorts of questions.

In using the learners' responses to the items of such an instrument, there is little point in adding them even within the four broad headings of Awareness, Understanding, Values and Skills. They are not scales and information is lost by such aggregation. They do provide the basis for interesting profiles of the learners that can be useful feedback to the teacher about those parts of the teaching that have been effective.

UNIT XIX : EVALUATING ENVIRONMENTAL LEARNING

Objectives	Environmental Education Aims
(1) to develop students' awareness of different types of assessment	. to help students acquire an awareness of and sensibility to the total environment
(2) to develop students' skills in item writing	. to help students acquire social values and strong feelings of concern for the environment
(3) to provide practice in the potential use of items	. to help students develop the skills necessary for investigating the total environment

Science Process Skills	Pedagogical Techniques
classifying, communicating	committee work, small group discussion

Preservice Teacher Needs

(1) to feel confident in assessing affective objectives

(2) to feel able to design assessment items

Resources	Suggested Time
Exemplary items	2 hours

SUGGESTED APPROACH

It is probably most productive in this unit if the pre-service teachers work in small groups of 2-4 members.

The science teacher educator of each group chooses a broad environmental problem that involves science knowledge from some level of secondary schooling. (e.g. disposal of litter, see page 122).

Step 1 Measures of Awareness

Each group is to construct four items with the form:

Statement	Strongly Disagree				Strongly Agree
	1	2	3	4	5

The statements should be claims that relate to the chosen problem; (i) and (ii) are two levels of awareness of the problem; (iii) indicates that the learners' choice of action in relation to it affects others and (iv) suggests that the learner has some potential to act in relation to the problem.

Step 2 Measures of Understanding

Each group should now construct four items that set out to measure the learning of cognitive information re the problem that has occurred as a result of teaching. The item forms below can be used, although many of the common forms in science teaching can apply to this aspect of the learning.

Form 1

Define and explain "concept A" that is important in some part of the chosen problem.

(a) State

(b) Explain

Form 2

State clearly two problems in this community that relate to the materials and energy aspects of the chosen problem and indicate the sorts of solutions that have been suggested for them.

	Problems	Solutions
Materials	a b	a b
Energy	a b	a b

Step 3 Measures of Values

For these the form of measure proposed is as follows:

> *You will be shown a series of slides that have to do with the chosen problem. List what you like and dislike about each picture.*

Each group is to decide on four scenes related in some way to the problem and its solutions that could provide suitable slides.

Step 4 Measures of Skills

Each group is to design a response sheet that could be used to record the learners' abilities to:

1) *recognise general problems using the slides prepared for measure 3.*

2) *define specific problems in the learners' community that are aspects of the chosen problem.*

3) *know where to obtain information relevant to the problem.*

4) *state alternative solutions to several specific problems.*

Evaluation of Curriculum Materials

Another type of evaluation has been developed that is important for science teachers wishing to contribute to environmental education. Many curriculum materials have appeared that are now claimed by their developers to have a usefulness in environmental education. Many commercial publishers and other sources of learning resources recognise important movements in education such as the environmental one but they do not always fully appreciate their character. Accordingly, some so-called environmentally-oriented materials do not measure up to criteria that are related to the characteristics set out in Units III and IV.

In Unit III we referred to the IUCN definition of environmental education. Its stress on the inter-relatedness of humankind, on many cultures and on the bio-physical surroundings, has been quite fundamental to what this book means by environmental education. If teachers wish to teach environmentally, the materials their students see and hear and read should make explicit this basic point. The next Unit in this chapter introduces science teachers to the use of an evaluative instrument that can easily be used to check on this feature and a number of the other characterisitcs of environmental education.

UNIT XX

ENVIRONMENTAL EVALUATION OF CURRICULUM MATERIALS

INTRODUCTION

As part of a national survey of environmental education, Linke* developed the rating sheet in Figure 5.1.

Title and Source of Curriculum Materials: ____________

Date and Source of Newspaper Report: ____________

	INDEX	RATING					COMMENTS
I	Explicit emphasis on human/environment interaction	0	1	2	3		____________
II	Qualitative Classification	--	-	0	+	++	____________
III	Conservational Approach	-	0	+			____________
IV	Emotive Intensity	0	1	2	3		____________
V	Quantitative emphasis	0	1	2	3		
	(1) General						
	(2) Environmental						____________
VI	Pictorial emphasis	0	1	2	3		
	(1) General						
	(2) Environmental						____________
VII	Cognitive Processes	0	1	2	3		
	(1) General						
	(2) Environmental						____________
VIII	Practical Activities	0	1	2	3		
	(1) General						
	(2) Environmental						____________

ASSESSMENT BY: .... DATE................

Figure 5.1 Rating Sheet for Indices of Environmental Education

* R. Linke (1980), "Environmental Education in Australia: Allen and Unwin.

Most of the indices are self-explanatory once the first one is properly understood. This one, the explicit emphasis on the interaction between human persons and the environment, is related to this fundamental part of the IUCN definition of environmental education (see Unit III).

The rating of a text-book or some other form of curriculum material is done according to a key.

The index is used, when rating say a text-book, according to the following key:

0 No explicit reference to the interaction

1 Rare or isolated reference

2 Occasional reference

3 Frequent reference

The second index, Qualitative Classification, refers to the ways in which this interaction is referred. In other words, if the only examples of interaction with the environment were implied as "good" then it would rate + or ++ depending on their number. If on the other hand, there are examples of negative or harmful interactions then the rating would be - or --. Both sorts of interactions can be rated together.

This type of rating is also used with the third index, Conservational Approach. This records whether or not the interactions that are emphasised are primarily conservationist in character. If so the rating is +. A negative rating could arise from either interactions that consume resources or damage the environment.

Index IV, Emotive Intensity, recognises that if values and commitment are integral intentions of environmental education, then emotive protrayal of various kinds can be included in resource materials and can in fact, assist the teachers' efforts to discuss the values that various groups bring to an issue.

Index V refers to the absence or presence of quantitative data (measures or statistics) in the material and Index VI rates the content to which visual material (photos, drawings, diagrams) are present.

Index VI is related to those cognitive aspects that have been referred to in this module as Concepts and Processes. Index VII provides an opportunity to record whether the materials explicitly suggest forms of active learning such as would lead to the acquisition of practical skills or experience in social action.

For the last four indices there is an opportunity to record whether the rating is of general science content in the materials and/or of its environmentally-oriented content.

This unit is to provide the pre-service teacher with practice in the use of this rating scale.

It should be stressed that there is no absolute score that gives a particular rating. Rather the usefulness is as a relative rating procedure and in this way it also serves to introduce teachers to the variety of sorts of materials that could be helpful in their teaching.

UNIT XX - ENVIRONMENTAL EVALUATION OF CURRICULUM MATERIALS

Objectives

(1) to reinforce the students' ability to identify to basic feature of environmental situation.

(2) to provide the student with the ability to recognise differences in materials.

(3) to develop the students' sense of how environmental situations can be presented.

Environmental Education Aims

- to help students develop a basic understanding of the total environment and the inter-relationships of man and the environment.
- to help students identify alternative approaches and make informed decisions.

Science Process Skills

classifying, interpreting data, inferring, measuring

Pedagogical Techniques

(i) individual tasks followed by small group negotiations and discussion.

Preservice Teacher Needs

(1) to feel confident about choice of curriculum materials.

(2) to feel they can recognise curriculum resources for environmental education

Resources

Worksheet

Curriculum Materials

Suggested Time

1 hour, followed by another 1 hour after a period for the rating to be done.

SUGGESTED APPROACH

Step 1 Hand out the Worksheet that contains the rating set of indices.

The science teacher educator should explain each of the indices and the use of the key, by means of a pair of familiar school science texts or books, that provide a good contrast on at least some of the indices.

This will include (i) clarifying the meaning of the descriptions used on the Worksheet, and (ii) explaining how the "qualitative" (+, -, 0) and the "quantitative" ratings (0, 1, 2, 3) are made by a relative rather than absolute process. It is, in a sense, the density of examples of environmental interaction that is being considered. For pre-service science teachers the idea of density may be a helpful analogy.

Step 2

Each pre-service teacher should then be allocated a booklet, an environmental kit, a text-book, a game, or some other piece of curriculum material. Several members of the class should be given the same material to evaluate. They are then instructed to read through the materials either now (if they are available) or in the library before the next session.

Step 3

After the rating is complete, groups should be formed of those who rated the same material. Their respective ratings should be discussed and differences used to clarify the meaning of the indices and their use. Each group should then be asked to comment briefly to the class on how useful they felt the materials to be for environmental science teaching.

Step 4

As a follow-up to the analysis of these formal resources for school education, the teacher educator should then get the pre-service teachers to rate accounts from the newspapers of environmental issues that have occurred recently in their owr society.

UNIT XX

ENVIRONMENTAL EVALUATION OF CURRICULUM MATERIALS

WORKSHEET

For the example of curriculum materials allocated to you, complete the rating sheet below after you have read it through and examined the materials for the content implied by those indices.

Title and Source of Curriculum Materials: ______________________

Date and Source of Newspaper Report: ______________________

	INDEX	RATING	COMMENTS
I	Explicit emphasis on human/environment interaction	0 | 1 | 2 | 3	
II	Qualitative Classification	-- | - | 0 | + | ++	
III	Conservational Approach	- | 0 | +	
IV	Emotive Intensity	0 | 1 | 2 | 3	
V	Quantitative emphasis (1) General (2) Environmental	0 | 1 | 2 | 3	
VI	Pictorial emphasis (1) General (2) Environmental	0 | 1 | 2 | 3	
VII	Cognitive Processes (1) General (2) Environmental	0 | 1 | 2 | 3	
VIII	Practical Activities (1) General (2) Environmental	0 | 1 | 2 | 3	

ASSESSMENT BY: .... DATE................

Evaluation of Teaching for Environmental Education

It would be incomplete to conclude this chapter without some reference to some means of evaluating the teaching aspects of a science curriculum that does mean to include an environmental contribution.

Throughout the earlier chapters of this mocule it has been stressed that it is possible for science teachers to contribute on many occasions during their regular science teaching to the environmental education of their students. It has also been pointed out that this contribution is part of, and only part of, the total task of teaching science. This part is characterised, it has been argued, by some quite distinctive features and objectives and a number of suggestions have been made as to how these learning goals might be achieved. For example, the emphasis in environmental education on communication requires that learners should have many opportunities to express themselves, to try to argue a case, to try to explain and to ask questions in order to comprehend other viewpoints. Again, the stress on values and attitude formation means that some use needs to be made in the pedagogy of the classroom of those techniques that encourage value clarification, peer group influences, and the identification of moral dilemmas and issues of controversy. In Chapters 3 and 4 many of these types of pedagogical practices have been suggested in the units so that pre-service science teachers will have practiced them prior to using them in the classroom. Then there are activity-based teaching situations such as the environmental trail and the field trip where the pedagogy has moved out of the classroom scene.

It will be useful for all science teachers who have a serious intent about environmental education to check periodically whether they are including in their pedagogy these various methods. In Table 5.1 such a check sheet is presented.

Have I included in my classroom pedagogy	Yes/No	How successfully
Brainstorming		
role playing		
buzz groups		
small group discussion		
debates		
listening to a point of view		
explaining or arguing in pairs		
practising an interview		
letter writing to community authorities		
moral dilemma presentations		
committee work		
Have I made use of		
simulation games		
questionning community environmental experts		
media imitation		
questionnaire development		
community persons affected by environmental damage		
the environmental issues of the classroom		
the environment just beyond the school		
an environmental trail		
a field trip		

Table 5.1 Check list for self-evaluation by teachers of the strategies and techniques for environmental science teaching

CHAPTER 6

IMPLEMENTATION OF ENVIRONMENTAL EDUCATION AT THE SCHOOL AND SYSTEM LEVELS

Environmental education as it has been defined in this book does differ in a number of ways from traditional secondary education.

If the challenge of environmental education is to be met through the subjects of the secondary curriculum, a number of conditions will need to be met. Hitherto, in Chapters 2, 3 and 4 of this book there has been a concentration on the skills and knowledge that a science teacher will need to implement an environmental emphasis in his/her science classes. However, there will always be a number of constraints against such implementation and much of the efforts by individual teachers will be of no avail or could be rendered ineffectual unless there is a strong support for environmental education from their school authorities and beyond that from the educational system and the community.

In this chapter these constraints and supports beyond the individual science teacher and his/her classroom are considered. These will vary to some extent from country to country and one of the tasks of persons using the module or trying to implement environmental education will be to list the sorts of constraints that are most likely to apply in their own situation.

The chapter is presented differently from the earlier ones. Primarily it is addressed to persons other than science teachers and in particular pre-service science teachers. Accordingly, it does not have the structure of a number of separate units that can be used as part of a pre-service or in-service training programme.

The target of this chapter is all those persons who shape and determine the tasks that science teachers have to perform. In the school situation there are other colleagues and very importantly the head teacher or principal. The parents of the learners also exercise considerable influence in many situations either through direct involvement in school management and policy or less directly through expectation and more subtle pressures that condone some types of schooling and reject others.

In the wider educational system there are both people like Directors, Inspectors, Science Consultants, and other resource providers. There are also policies that restrict some practices and encourage or sustain others. The provision of well stocked laboratories is an example of something that is usually beyond the school (and certainly beyond the individual science teacher) to determine. The presence or absence of such resources clearly influences strongly the sort of science education that a teacher can provide.

Finally there are still wider community authorities who can constrain or support the efforts of those who teach in schools. Among these are civic leaders and experts who can also contribute if they will to an emphasis like environmental education. Those responsible for mass media and religious and cultural patterns are also very important to any type of education that suggests or involves interaction with society as environmental education so clearly does.

The chapter sets out to raise the issues of constraint and support because they are so important to the success of an innovation like environmental education. We believe these need to be taken up with all the sorts of people that are listed above. The opportunities for doing this vill vary from country to country and from school to school. For this reason also, the chapter is not given any rigid form that would make it inappropriate. It will be up to users of the module to determine how it can be used.

In any use, we believe four phases need to be stressed if successful implementation is to occur. These are *Recognition, Identification, Responsibility* and *Maintenance.* These phases are named according to the process to be undertaken in them.

Recognition is the process of getting persons in positions of power to accept that they can influence (positively or negatively) how science teachers teach in their classrooms. In the case of this module, they can do much to facilitate or repress an environmental dimension in science teaching.

Identification is the pair of processes of pin-pointing certain specific constraints against environmental teaching of science that presently exist in the educational situation and of proposing means of reducing or removing these.

Responsibility is the determination of who (actual persons) can alter the constraints and will accept the role of doing so.

Maintanance is the ongoing process that means that positive support emerges for the innovation rather than merely removal of constraints. It will be concerned both with maintaining morale in the science teachers for their task and with maintaining an information flow so that all these persons who now are willing to provide support know how and when to do so.

Science teachers will have a part to play in each of these processes because it will often be them who will have to provide the information about what environmental education is and what they need to carry it out.

In the next section an example of a type of environmental education is used to amplify the process of Recognition.

Recognising Constraints - an example.

As an example of these constraints, it is helpful to consider the implications of environmental education being concerned with the environmental problems in real situations. One obvious way for the teacher to ensure the sense of reality is for he/she and his/her class to visit the sites of environmental situations that are readily accessible to the school. This could involve a field trip of the type that was developed in Unit XVI. That unit deals with the planning and implementation of a field trip but there are other problems associated with field trips that are not covered in that unit. These vary from society to society but in most societies there are substantial constraints against the easy use of this rather special type of pedagogy. Usually a number of special conditions need to be met if permission is granted for a class to have a field trip. Among these is the cost that is incurred if the field trip involves a journey by bus or train. Who is to pay and how will this be equitably borne so that some students are not excluded? Even if no cost is involved there is the cost in teachers and in time. A teacher may normally teach a class of 20 or 30 or 40 students or even more in some countries. It is quite impossible for one teacher to take those sorts of numbers on a field trip and maintain its educational value. So several teachers are necessary on the field trip and this makes the school short of its usual complement of staff for the remaining classes. Some school systems will provide temporary replacements, but many others expect the school to cover any such event with its existing staff.

Again, it would be a rare field trip (except to the school's grounds) that could be completed in the normal time allocated for a science lesson in a day's time-table. This means that the students on a field trip will be unavailable for their other subjects during this period of time and co-operative adjustments to the time-table will need to be made. The presence of some of these other teachers on the field trip would of course be a great advantage if it was possible because they would then be able to relate its experiences to their own subject teaching.

Then there are the legal liabilities that may apply to a school (and/or to teachers) if accidents occur on a field trip. These can be quite different to those that apply to the classroom situation and may need special consent from parents, etc. Parents may need special explanations if they are to understand, appreciate and give consent to these sorts of learning experiences that fall so far outside their own experience and expectations of schooling.

Finally, a field trip will not be possible to many environmental situations without the co-operation of the authorities and members of the community in those locations. The responsibilities of these authorities must be recognised by the teachers and their students and permission sought where necessary. The rights of the ordinary members of any local community must also be respected and teachers and students must take care about the attitudes they expose to them and the demands they may be making.

We have dwelt at some length on this one type of environmental education, because it has so many obvious aspects that lie beyond the capacity of a science teacher to provide. If the support to overcome these constraints is forthcoming from his/her authorities, the wider school system and the community itself, the science teacher with colleagues will no doubt do most of the detailed arrangements. Science supervisors and science inspectors who appreciate these broader implications of this very useful technique in the pedagogy of environmental education have a major task here to ensure that these authorities also understand these requirements and hence provide the appropriate support.

Many other characteristics of environmental education will also require school, system and community support for the classroom teacher. Indeed, it should be noted that the environmental field trip that has just been discussed is in many ways not so unusual for science teachers.

Many science teachers, particularly when teaching certain biological or earth science topics, will have had some experience of conducting lessons on location outside the classroom and away from the school.

Identification of Constraints

It has already been stated that particular constraints and supports for environmental education will vary from country to country and from school to school. Thus it will not be useful to go into too great a detail about the constraints that we as authors have identified in our own educational systems.

It has, however, been possible to review a number of programmes for environmental education from different countries and extract a list of common broad sources of constraint. Table 6.1 contains this list. It also has a blank right hand column for the insertion of the particular form these take in a local situation and other sources that apply. In this form the Table may be useful in working with groups about this phase in the implementation of environmental education.

Most constraints are self-explanatory but one does seem worthy of further comment. This is the "unavailability of the school as an environment". It is quite remarkable how many teachers are trying to teach environmentally in schools where the school as a biophysical environment is ignored. Accordingly we believe there must be very strong constraints that cause this situation to occur. The staff of a school may have enthusiastically included energy conservation in its curriculum but give no attention to the school community's consumption and waste of energy. Most schools have buildings and some sort of surroundings as environments about which decisions could be made as part of the students' learning.

School councils or Education Departments may endorse the general idea of environmental education but not give permission for any of their authority about the physical environment to be transferred to teachers and students. It seems that a School Environmental Education policy is still a rarity in most countries.

Broad sources of Constraint	Particular forms of Constraint
Inadequate curriculum materials	
An avoidance of values	
A strong disciplinary orientation	
Inflexible scheduling	
Teacher education	
Lack of community reinforcement	
Rigid instructional guidelines	
General apathy	
Funding	
A Back to the Basics emphasis	
Traditional forms of Assessment	
Too few role models	
Inadequate time availability	
No experience of teacher co-operation	
Lack of administrative support	
Confinement of schooling to the classroom.	
Unavailability of the school as an environment	
Insecurity about out-of-class teaching	
Controversy seen as uncomfortable	

Table 6.1 A listing of constraints against an environmental dimension in schooling.

Suggesting Solutions and Naming Responsibility

One useful format for the decisions that need to be made in the second process of the Identification phase and in the Responsibility phase is shown in Table 6.2.

Priorities for Change (What)	Proposed Action (How)	Personnel (Who)	Time Scale (When)

Table 6.2 A format for lessening constraints.

It is most important that the listing of constraints not be allowed to overwhelm. In any situation for environmental education, many constraints will easily emerge if the Identification process is taken seriously. It should always be remembered that some teachers and some schools are already achieving much more than others despite the constraints.

Along with the process of listing constraints a sense of priority should be developed. A few constraints need to be isolated out as prime targets for change. They should be ones that can be seen to be alterable. More difficult-to-change constraints will be different if the whole pattern of environmental education is more established. Removel of any constraints, however limited, will assist this establishment.

Once a few priorities are established for change, it is necessary to consider the alternative procedures that may bring about changes. For each, certain personnel will be the target agents of change since they either have influence or authority. A time scale is also useful if realistic change is contemplated.

Maintenance of Environmental Education

Lessening constraint is one way to enhance implementation but the development of positive supports is a much surer way that innovations will be sustained. One very helpful form of support that will illustrate this process of maintenance is the formation of a School Policy for Environmental Education.

Countries differ in the extent to which people outside the teachers and learners become involved in the affairs of schools. In the

U.S.A., in general, there are a number of ways parents and citizens are expected to be involved. In Papua-New Guinea, some village committees will have had very little formal experience of involvement.

A School Policy for Environmental Education assumes that a whole school community, not isolated teachers, is the effective group for making such an educational contribution and that the active participation of a school's local community is both desirable and possible. Each community, and each school in its turn, will have to determine for itself the appropriateness and the level of this participation.

If a Policy is to be effective it will need to be made by those whom it affects and by those who hold power in the situations of its operations. They will need to be brought together for purposes of information, development of commitment, formulation of policy and decisions about it. In other words, many of the steps of environmental education in Chapter 3 will need to be gone through.

The needs of the environment will have to be put in very direct and practical terms. This will involve a restatement in local terms of that concern that was so well encapsulated in the following words from the U.N. 1972 Declaration on the Human Environment -

> *We see around us growing evidence of man-made harm in many regions of the earth: dangerous levels of pollution in water, air, earth and living being; major and undesirable disturbances to the ecological balance of the biosphere; destruction and depletion of irreplaceable resources; and gross deficiencies harmful to the physical, mental and social health of man, in the man-made environment, particularly in the living and working environment.*

The examples of environmental issues will need to be so chosen that the way the school could contribute and the benefits to it and the community are very clear. Likewise, the possibilities for how environmental education can enhance and improve the school's curriculum should be stated in concrete terms. Finally, the general conditions under which the contribution can be made will need to be acknowledged.

If these processes are achieved with the appropriate people, a School Policy may result. It will be some sort of statement, in lay terms, of aims and values about the environment, of commitment that the School will make a contribution through teaching and learning, and of some of the arrangements that will be made to support this.

The Policy will also need to set up mechanisms for an ongoing flow of information so that the education remains dynamic, feeding into and receiving from the local community. If such mechanisms work they will lead to good morale among teachers because they will not be isolated and unrecognised. They will find themselves partners with others in an enterprise in which they have an essential role but in which they are not alone. When help is needed they will know where to turn. When they have a contribution to make to the community of the school, it will be expected and not experienced as an unexpected threat. When the communities see a need for education, they will turn to the school and call on its (and their) teachers.

Other Characteristics Needing Support

Features of environmental science education that do have obvious constraints in many countries are (i) the involvement of persons who are not normally involved in schooling, (ii) the "action" objective, (iii) the use of pedagogical methods that are not common in many traditional science classrooms, and (iv) the interdisciplinary nature of the environmental situations.

These will not be discussed at length but for each one, in different ways in different countries, the classroom science teacher will need help, support and legitimation. At the highest levels of education this help, the supports and the legitimation have been approved. The Tbilisi Conference in 1977, as a culminating point of the first phase of the Unesco-UNEP International Environmental Education Programme (IEEP), was a meeting at the Intergovernmental level. It was the occasion when the authorities of the participating countries acknowledged environmental education and formally pledged support for it.

However, there is a very wide gap and a substantial time lag before this level of legitimation and pledge of support becomes a reality for the average practising science teacher in school. It is not this teacher who can be expected to bridge these gaps. Directors of Education, curriculum authorities, science supervisors, and science inspectors have special responsibilities to develop policies, programmes and those material and personal support structures that will turn these governmental intentions into real help for the people responsible for individual schools and for the classroom teachers who ultimately present these to the pupils.

A few comments on these four aspects will, hopefully, serve to stimulate readers in various countries to provide the details of how these aspects appear in their own situations.

It has been repeatedly stressed in this module that environmental education is a response or contribution to something real that exists outside of schooling and indeed outside formal education as a whole. If schooling is to make this contribution it will need to draw on the expertise and experience of persons who know these environmental situations and problems at first hand. This type of partnership is unusual. In traditional education the teaching partnership is between teachers and existing knowledge. Such a partnership is available to teachers and school systems through their own personal expertise and training or through books and other curricular resources. In the case of environmental situations the teachers' expertise is that of education and it is other people who have expertise of the situations (knowledge plus experience). In the case of a local environmental problem, it is evident that the science teacher's twenty or thrity students (and their families) will have much more knowledge and experience of the problems than he or she could possibly be expected to have. Likewise there will be other experts and other participants in the real situations who will need to be consulted as we have indicated in a number of the units in the module. Individual science teachers will need sanctions and support from their school authorities and from system-wide science teaching consultants as they seek this co-operation with the environmental "experts" for their teaching.

Whatever "action" outcomes for school environmental education are appropriate in particular countries, they will rarely have been part of the traditional pattern of schooling. Some like the "junction" event that is the subject of pages 136-138 only involve the wider school community but again this will require permission and support from the school authorities. Science supervisors and inspectors can prepare school authorities for such possibilities as they go about their rounds and feed information to schools about these new sorts of curricular emphases. These professional educators from outside particular schools can also be very helpful to teachers by sharing their experience of the range of social action that is both acceptable and effective.

Physical science teachers, in most countries, have not yet begun to use small group discussion as a common teaching approach. A number of the new biological science curricula do suggest it. As will be clear from the units in Chapters 3 and 4 particularly, environmental education in the science class is likely to draw heavily on these forms of pedagogy. This will mean science classes may become more "noisy" and could appear to be less controlled than usual. Once again science supervisors as they visit schools can help to familiarise school authorities to these sorts of changes in the milieu of the school.

Finally, although we have emphasised that environmental education should and usually will occur through the teaching of existing subjects, it is important, as the model of Unit V clearly indicates, that science teachers do periodically involve other subject teachers so that the interdisciplinary character is stressed. In many countries science in school is still taught vary discretely as physics, chemistry and biology. In these cases, the first level of interdisciplinarity will require co-operation between these science teachers who do not normally have to inter-relate to carry out their teaching responsibilities. The sanction and legitimation for this will come very effectively from science supervisors and inspectors who are themselves enthusiastically committed to environmental education.

At the time of the Tbilisi Conference a number of countries reported the establishment of various supports for teachers. Among these were regular lectures on environmental issues by scientists and other experts, system-wide field study centres (both urban and rural) manned by teachers with environmental expertise, teacher consultants associated with other government departments and authorities (like forests, energy, wildlife, national development, etc.) who act as information liaison persons, some environmental curriculum development projects, and both pre- and in-service teaching training programmes. Most of these are not yet well established in most countries, and science supervisors are again key persons in fostering and developing them.

APPENDIX 1

SCIENCE CONCEPTS OF PARTICULAR IMPORTANCE IN ENVIRONMENTAL EDUCATION

Introduction

The following six sections introduce a range of concepts relating to the environment. Each is defined and accompanied by relevant examples, together with some suggested student activities: This section makes use of material found in G. Tyler Miller's "Living in the Environment", published by Wadsworth Publishing Company, California, U.S.A. to whom we are indebted. The first and second editions of this book are strongly recommended as additional material for readers.

For most pre-service science teachers, the availability of this information should serve to reinforce knowledge gained in earlier courses. Introducing concepts through active learning can reinforce didactic teaching, so a number of suggested student activities have been included. These can be used at the discretion of the science teacher educator as each situation requires.

A 1.1 ENERGY

Energy is a word that is heard almost every day in many parts of the world. Like most common words it is often used in different ways to express different meanings.

Since the early 1970s, newspaper and other media have repeatedly referred to an "energy crisis" or an "energy shortage". Slightly more technical reports refer to the "amount of energy" consumed per person and relate these to known "energy reserves".

"Energy" is said to be a basic resource but there is also much talk of "alternative energy sources". A number of campaigns to "conserve energy" or to lessen the "wastage of energy" have been launched at the domestic, the company, the community and the national levels.

In personal life we speak of "having no energy" or "being energetic". These phrases usually relate to the actions of getting little done, or of bustling around and getting a lot done (or at least getting things moving). In social and public life we now associate energy with movement (petrol, oil and coal as sources of energy used in transport) and with heating and cooling (burning fuels like wood, coal, peat, dung, and the use of machines like heaters, coolers, fans, air-conditioners, etc., that involve electricity).

Throughout human history, people's use of energy has varied and developed. In many ways the changes in the use of energy by humans co-incide with the major changes we use to describe civilisation's progress. Starting with fire which was used for warmth, light, protection and in preparation of food, human beings found that their own "energy" could be extended in many ways. Thus, through the use of machines of many sorts, through running water or wind, through new fuels besides wood (like peat, coal, oil, and very recently uranium), and overwhelmingly through the use of a secondary source, electricity, the way of life of almost all societies has been transformed very considerably. Plant and animal husbandry are two major human endeavours that lead to secondary sources of energy and hence provide us with a degree of control over the primary source, sunlight.

Other consequential sources like tides and ocean temperature gradients, and sunlight itself have been used for many puposes throughout history. Now, there is much more attention being devoted to harnessing these "energy sources", as those on which we have relied so heavily shrink under the ever-increasing demand humanity is putting on them.

Science has contributed very greatly to our ability to use energy and to our understanding of what is involved in energy use. As usual in science, the power it provides to people increases as its descriptions of phenomena become more precise and as more of them can be linked together through underlying and general ideas or concepts.

Today in science, <u>energy</u> is used as the concept that underlies the idea of change. When we grow, when a train slows down, when water evaporates, when leaves change colour, when a coastline erodes, we say that each of these phenomena will have involved the transfer of energy.

For some of these changes, it has been helpful for scientists to think of "energy" as some sort of thing that passes or flows from one region or system to another adjacent or surrounding one. This was a very popular way to think of energy in the 19th century, but in this centruy, scientists have found that this view has limitations for a number of changes. Alternative views have developed in which energy is an explanation of change and a measure of the extent and direction of change.

Kinds of change and types of energy.

Some common kinds of change are used to provide a classification of energy.

1. When an object moves faster it is in a higher kinetic energy state.

2. When an object is separated from the surface of the earth, the object/earth system has a greater gravitational potential energy. Likewise, when positive and negative charges are separated from each other the pair have a higher electric field energy or a state of higher electrical potential energy.

These are the two main forms of energy. A number of other kinds of change are often described as particular energy types but these are combinations of the two basic forms, kinetic and potential.

For example, increasing the amplitude of a vibrating pendulum or an oscillating spring or atom is said to increase its vibrational energy state (a combination of varying kinetic and potential energy states).

Or, changing the state of matter, or the chemical composition of a system alters its internal energy state or its chemical energy. Raising the temperature of these systems also increases its state of internal energy. (Again this combines both kinetic and potential forms.)

Thus, the energy state that an object occupies by virtue of its position, condition or composition is known as its potential energy. Coal, oil, natural gas, wood and other fuels have some of their energy in the form of potential (or stored) energy. When the fuel is burned, this chemical potential energy is transferred as heat to the molecules in the air and to other nearby molecuels that result from the fuel's burning. These molecules are excited (hence emitting light) and also increase in temperature (i.e. kinetic energy of motion).

Mechanisms of Energy Transfer

Two basic mechanisms for the transfer of energy exist, and both can be used to effect changes. Whenever energy transfer occurs by the exertion of a force over a distance, the mechanism is called WORK or WORKING.

When energy is transferred from one system to another by a change in temperature, the mechanism is called HEAT or HEATING. (Heating can occur by convection, conduction or radiation or combinations of these.)

In a power plant generating electricity, the chemical potential energy from fossil fuels (coal, oil or natural gas) or the nuclear potential energy from nuclear fuels is transferred as work to spin a turbine (kinetic energy) and as some heat to raise the temperature of the surroundings. The turbine then transfers its kinetic energy as work to produce a separation of electrical charge (electrical potential energy) and some more heat to the surroundings. When this electrical potential energy transfers to the filament wires in an ordinary light bulb, some of it is by heating and the temperature of the filaments rises so that they emit light as well as transferring again heat to the surroundings. In all these energy transformations it should be noted that some energy always ends up as heat, energy that flows into the surrounding environment in accord with the law of energy degradation (see below).

The Characteristics of Energy Transfer

There are many different ways of bringing about changes. Two fundamental laws describe the energy transfers that are involved, however the changes occur.

1. If any system changes to a state of lower energy, other systems will change to states of higher energy in a way which conserves the overall energy. That is, however changes occur, the net change in the energy states of the systems involved is zero. In science this is spoken of as the Law of Conservation of Energy.

2. No matter how a change is designed to occur, some of the energy will be transferred as heat to unintended parts of the system or to neighbouring systems. Frictional effects are one of the very common sources of this unintended heating which raises the temperature of the wider surroundings. This inevitable inefficiency in the transfer of energy is known as the Law of Energy Degradation. Whether it is riding a bicycle, or operating a power generating plant, or a manufacturing industry, we can calculate an efficiency for these change processes with the formula

$$= \frac{\text{Energy transferred in desired way}}{\text{Total energy transferred}} \times 100$$

When 100 units of energy contained in coal are converted into electricity in a power plant, the amount of electrical potential energy produced in only about 30 units, the remaining 70 units having been "lost" or degraded as heat in the process. Such a process is, using the above formula, only 30 per cent efficient. Efficiency in this case means the energy still available for work at the end of the process, as a percentage of the energy at the beginning of the process. However, in the sense of the conservation law, the original 100 units still exist in the 70 units transferred as heat and the 30 units still available for work.

In everyday use, "energy conservation" refers to plans (or various alterations to existing practice) that aim to lessen energy degradation (i.e. efficiency is increased). For many human processes of change, the energy degradation is very large and there is great scope for improvement of efficiency.

For example, many houses in all parts of the world are poorly insulated and badly located as far as sunlight is concerned. In winter, substantial energy transfers in the form of heating from systems at a higher temperature than the house are rapidly lost from the house to the larger and colder system outside. In summer, eaves over windows facing the sun often fail to exclude unwanted heating effects of direct sunlight.

Various estimates suggest that it should be possible to slow down our consumption rate of fossil fuels by a factor of as much as two without major changes in life style if we would only make greater use of known ways of improving energy transfer.

<u>The Availability of Energy for Work</u>

The concentration of matter in a high energy state enhances its capacity to be transferred as useful work. Thus the chemical potential energy in a lump of coal or in a litre of petrol, or the gravitational potential energy of mountain water concentrated in a dam, or the combined kinetic and potential energy in a system at a high temperature can all be transferred in the form of large amounts of useful work.

The energy of the same amount of coal dispersed in a low-quality ore, or of a large volume of air at slightly elevated temperatures, cannot be used to produce much useful work. <u>Concentrated</u> and <u>dispersed</u> are terms that are used to describe the difference between these sources of energy.

In the case of the coal-powered electricity generating plant, the low efficiency of 30 per cent is the cost of transforming one concentrated or high quality source of energy, coal, to another type, electrical potential energy. The latter, also a high quality or concentrated source of energy, can be coupled more easily than coal to various systems for useful purposes.

The transfer of solar energy to produce food is another example in which the law of energy degradation applies to each of a number of steps. Photosynthesis in plants transfers energy from the sun (via light) to the plant system, doing the work that is involved in producing sugar and many other molecules plus low-quality energy. If you eat plants such as rice, these chemicals, as high-quality sources of energy, are transformed within your body to other chemicals with lower internal energy, and in so doing transfer energy which you use to move your muscles, and to perform other life processes. Again, low-quality energy as heat is formed maintaining the temperature of our bodies and warming our surroundings. In each of these energy transfers, some of the initial high-quality energy is degraded into low-quality energy through a heating of the environment to slightly higher temperatures than it was originally.

Suggested Student Activities

(1) Study the following diagram (Figure 1) (from Miller: "Living in the Environment", first edition, p. 224).

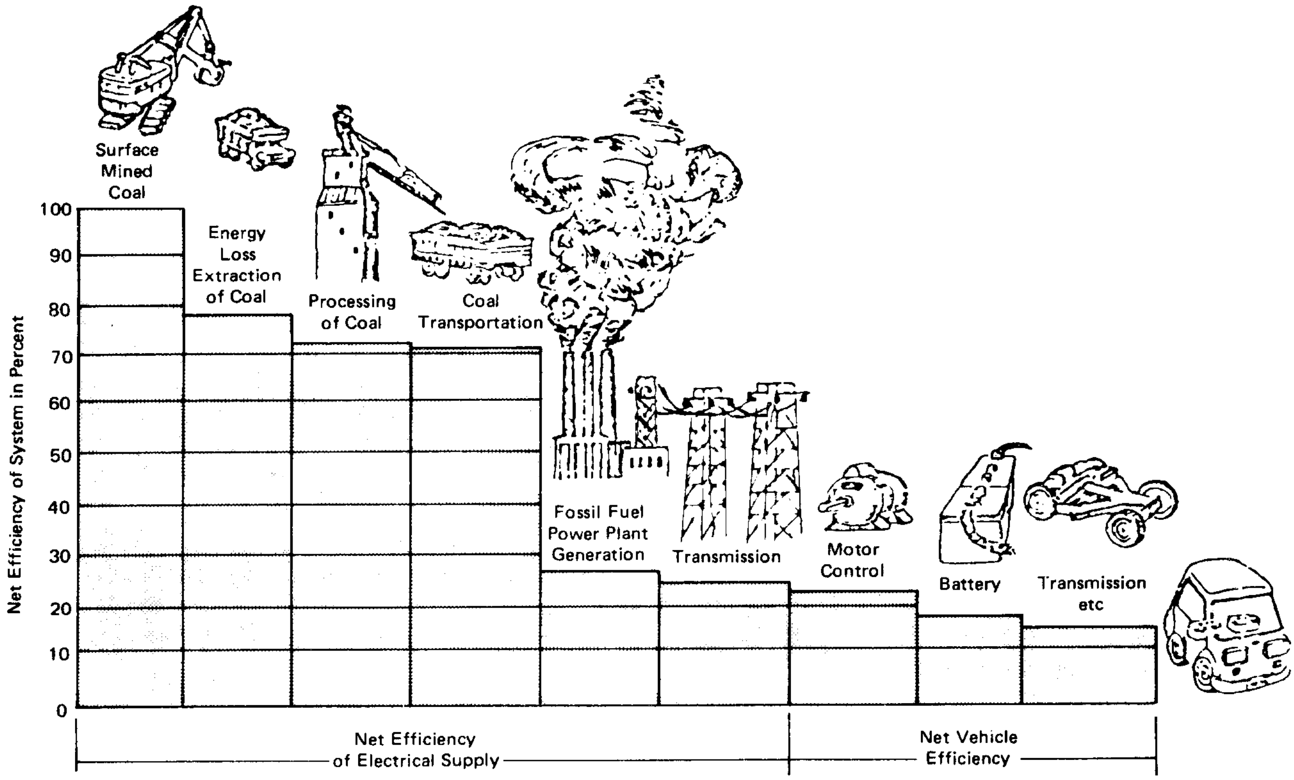


FIGURE 1: STAGES IN THE CONVERSION OF COAL INTO ELECTRICAL AND MECHANICAL WORK IN A CAR

Figure 1: Stages in the conversion of coal into electrical and mechanical work in a car.

Using the information in the diagram answer the following questions:

(a) calculate the efficiency of each process separately

(b) calculate (i) the efficiency of the electricity supply process

(ii) the efficiency of the vehicle itself

(iii) the efficiency of the total process in running an electrical vehicle.

(c) why are developed countries presently seeking to develop electrical cars in preference to petrol ones? (Assume that the overall efficiency of the process of producing and consuming petrol is 16 per cent.)

(d) Describe the energy transfers involved in the flow of water over a dam. How could some of the energy transferred be used to generate electricity?

(e) If possible obtain energy conversion figures for a hydro-electric power station and compare with the situation in Figure 1.

(f) List six different types of energy states that you have used today and classify each as kinetic and/or potential energy.

(g) The following are a number of ways of stating the two laws of energy.

First law of energy or thermodynamics (law of conservation of energy):

In any ordinary physical or chemical change, energy is neither created nor destroyed but merely transferred and changed in form.

or

You can't get something for nothing in terms of energy quantity, you can only break even.

or

There is no such thing as a free lunch.

Second law of energy or thermodynamics (law of energy degradation):

In all transfers of energy by means of work, some of the energy is always degraded to a more dispersed state, usually by heating the surroundings or environment.

or

You can't break even in terms of energy quality.

or

Energy can never be recycled.

or

Any system and its surroundings (environment) as a whole spontaneously tend toward increasing randomness, disorder, (or entropy).

or

If you think things are mixed up now, just wait.

Take any one of these statements and describe (orally or in writing) how you would communicate it (i) to secondary school students or (ii) to members of the general public, so that they understood its importance and its relevance to everyday life.

(h) Figure 2 is a diagram representing the transfer of energy in the U.S.A. during 1973.

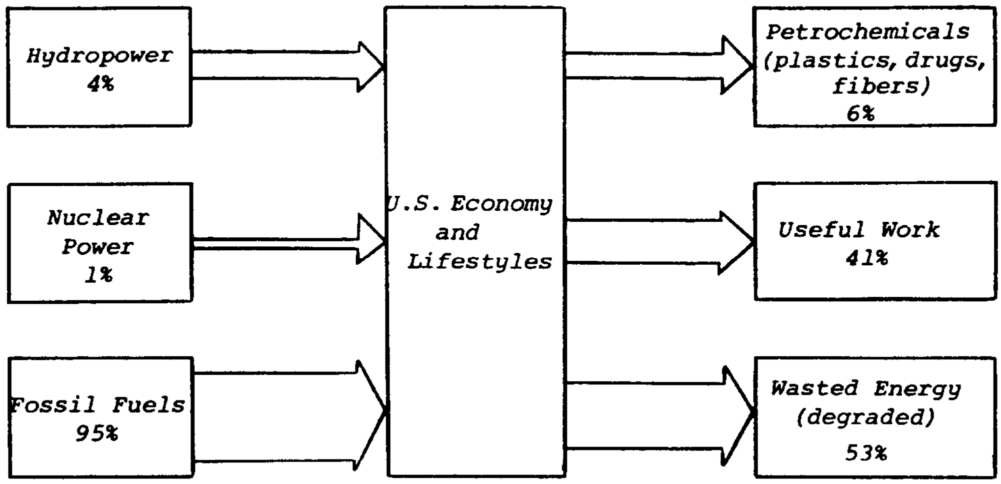


Figure 2: Transfer of energy in the U.S.A. (1973) from three different sources.

Construct a similar transfer chart for your country and compare the two. (If the data are not available do you think it should be, and why?)

UNITS OF ENERGY

The internationally recommended (SI) unit for energy is the joule (J). Since heat and work are interactions involving energy, the joule is also the unit for measuring these. There are, however, many other units in common use to measure energy in its various aspects. Since environmental issues will often be expressed in terms that are locally familiar, it is important that teachers and their students have facility in the inter-conversion of these units. Table 3 lists some of these other units for energy and their numerical value relative to one joule. The units for power (the rate of doing work) are also listed.

	S.I. Unit	Other Units
Energy (heat) (work)	Joule (J)	1 Kilowatt hour (KWH) = 3.6×10^6J 1 British Thermal Unit (Btu) = 1055J 1 Kilo calorie (Kcal) = 4187J 1 Calorie (cal) = 4.187J 1 Calorie (Cal in food) = 4187J 1 erg = 10^{-7}J 1 electron volt = 1.602×10^{-19}J 1 therm = 105.5×10^6J 1 kilogram force metre (kgfm) = 9.807J 1 foot pound force (ft lbf) = 1.356J
Power	Watt (W)	1 foot pound force per second (ft lbf/sec) = 1.356W 1 horse power (hp) = 745.7W 1 kilogram force metre per second (kgf m/sec) = 9.807W

Table 3: Units for Energy and Power.

A 1.2 ECOSYSTEM

What is an ecosystem?

A careful study of living things reveal that they are not scattered haphazardly over the earth's surface but occur in groups. A group of individual organisms, (e.g. monkeys, butterflies, palm trees) of the same kind (i.e. of the same species) is called a population. Depending on the size of the area being studied, a population may be all the rhesus monkeys on earth, or all of the rhesus monkeys in the area surrounding a village.

In any locality there are many different organisms, making up many different populations. The organisms can be plants as well as animals. All the populations of the plants and animals that live in a particular area make up what is called a community. In a community, the plants and animals interact with one another, as for example when an insect eats the leaf of a tree, or when a bird shelters inside a hole in a tree trunk. Members of a community living in the same locality therefore depend on each other for food and shelter.

Around the community is a physical environment made up of sun, air, water, soil, wind, etc. All members of the community not only react with each other, but with the physical environment as well, as for example, when spiders make use of the wind to start their webs, or when plants capture the sun's energy to make food (photosynthesis). It is the community of living things interacitng with each other and the physical environment which is called an ecosystem. The size of any ecosystem is arbitrary, ranging from a drop of pond water to the ocean, and in practice depends on the purpose for studying an ecosystem.

All the ecosystems on earth collectively make up the biosphere, which therefore includes all forms of life and all the interactions between living things and their physical environment which bind them together.

Energy Flow in Ecosystems

Survival of all living things depends on the circulation of energy. Human beings along with other animals get their energy from other animals or plants. Basically all animals depend on plants as a source of energy. Plants however (with few exceptions) get their energy from the sun. The flow of energy through an ecosystem forms an energy or food chain.

Starting with the sun's energy the first link or trophic level are all the green plants (and some bacteria) that can photosynthesise or "lock" in the energy into chemical compounds. Because they can make energy-rich compounds, or food, such organisms are called producers. They in turn are eaten by plant-eaters or herbivores such as insects, snails, cattle, etc., which make up the second link in the food chain. The third link is composed of animals which eat herbivores, the carnivores. They in turn could be food for other carnivores as occurs when hawks eat snakes, or where man eats crocodile meat. Eventually all plants and animals die, and their bodies are then broken down and consumed by decomposers. These include millipedes, earthworms and flies as well as micro-organisms such as fungi and bacteria.

From the second law of Thermodynamics, it can be accepted that no transfer of energy along the food chain, from one link to the next, is 100 per cent efficient. In general, it has been found that only about 10 per cent of the chemical energy available at one link in the food chain is transferred and made available to the next link. It is because approximately 90 per cent of the chemical energy is lost as heat, at each link in the food chain, that all life depends on the continual injection of energy from the sun. Energy, once degraded and lost as heat cannot be reused, and must be replaced.

The survival of an ecosystem depends on a continual energy flow through it.

Nutrient Cycling in Ecosystems

All life on earth depends on six essential chemicals - carbon, oxygen, hydrogen, nitrogen, phosphorus and sulphur. Together these six elements make up more than 95 per cent of the matter of all living organisms. Other elements such as iron, maganese, copper and iodine are also required but in much smaller quantities.

In ordinary physical and chemical changes (not involving nuclear reactions for example) it has been found that matter, like energy, is neither created not destroyed, but merely, changed from one form to another. This means that the amount of the elements that go to making up life is in fixed supply. How then are they made available for living organisms?

Unlike energy which flows in ecosystems, matter is continuously cycled through the food chains, and therby made available for succeeding generations of life. These cyclical movements of matter are called biogeochemical cycles and help to bind the ecosystems together.

Vast quantities of the six major elements are not found in plants and animals at one time, but rather remain in large reserves or reservoirs. For carbon, oxygen and nitrogen this is in the atmosphere whereas phosphorus, sulphur, calcium and others have large reservoirs of material in rocks.

In biogeochemical cycles, the rate at which it occurs is significant in determining the availibility of matter to be incorporated into the food chains. One of the most basic cycles is that of carbon, while phosphorus is interesting in that its continuing availability has been considered limiting.

(i) carbon cycle.

Carbon is a significant element in that is makes up nearly 50 per cent of living things. Carbon in the form of carbon dioxide has an average concentration of about 320 parts per million in the atmosphere (remembering that the concentration of carbon dioxide can vary daily, seasonally and in relation to local factors).

Carbon is taken in from the air as carbon dioxide mainly by producers which are photosynthesising. The overall process can be summarised:

carbon dioxide + water + solar energy $\rightarrow$ sugars (e.g. glucose) + oxygen

Many of the glucose and other organic molecules so formed are soon broken down by the respiration process in cells to release energy for cellular activities. This happens in plants as well as in the animals that consume them. In essence, the respiration process is the reverse of the photosynthesis process:

Sugar (e.g. glucose) + oxygen $\longrightarrow$ carbon dioxide + water + energy

While the carbon in carbon dioxide is returned to the atmosphere in this way by the respiration of the producers and consumers, by far the greatest amount of return is accomplished by the respiration activity of the decomposers in their breaking down of the waste materials and the dead remains of organisms from all trophic levels.

Not all organic matter is quickly decomposed, and that which becomes deposited in sediments in time becomes transformed over millions of years into peat, coal, oil and natural gas. These hydrocarbons when discovered, released and burnt by people causes the carbon (mainly as carbon dioxide, but also as carbon monoxide and other substances) to return to the atmosphere again.

Carbon is also a significant feature of aquatic systems. Carbon dioxide can diffuse between air and water, the direction being determined by the relative concentration. It also enters the water as a result of rain, with a litre of rain containing 0.3 cc of carbon dioxide. The reactions in water that follow are reversible depending on the concentration of the various components. As a result of this phenomenon the sea and associated waters is acting as a buffer for the large quantities of carbon dioxide that has been produced in recent years with the burning of fossil fuels. Instead of CO_2 level being as high as would be expected if all the CO_2 remained in the air, it is significantly lower, presumably because in response to the higher concentration in air, more is being dissolved in the water.

This is an example of how the structure and functioning of the biosphere masks some of the impact of more people and modern technology. A significant increase in the amount of carbon dioxide in the air could result in changes to the climate, with subsequent effects on food production, for example. Just because it has not happened yet does not mean we can continue to pump more carbon dioxide into the air and rely on other processes to control the effects.

What has been described is the merest outline of the carbon cycle. In practice there are a large number of pathways by which carbon is utilised, and an even greater number of pathways by which it is returned to the atmosphere. All of these pathways make up self-regulating mechanisms producing a relatively homoeostatic system.

(ii) phosphorus cycle

Phosphorus is important for living organisms because it is a component of genetic material (in the molecules of DNA and RNA) in all membranes, bones and teeth. Plants obtain inorganic phosphate from the soil, which is then transferred as organic phosphate to consumers and decomposers. This part of the cycle is rapid compared with the movement of phosphorus from the land to the sea and back to the land. The phosphate through decay and decomposition finds its way back to the soil, rivers and lakes and from there to the oceans. Most of the phosphate then forms insoluble deposits, which only become available with geological changes that produce an uplifting of these sediments.

An important pathway of phosphorus back from the sea to the land occurs with fish-eating birds. In regions like the coast of South America there are upwellings of ocean currents which bring nutrient-laden sediments within the reach of surface-dwelling plant life which provide abundant food for fish and other animal life. These thrive under the nutrient-rich conditions and in turn support fish-eating bird populations of cormorants, gannets, and pelicans. Their deposits, called guano, on islands or the adjacent coasts are important sources of phosphate. That phosphate which reaches deep ocean areas, however, is effectively "lost" as a resource (until such time as demand and new technology should change the situation).

At the present time, with the high use of phosphate fertilizer, the amount lost through erosion to the seas is large compared with the amount mined and returned to the land. This part of the cycle is being accelerated by the clearing of forests and other land-use changes. Although the world will not "run out" of reasonably available phosphorus for a long time, this serves as an example of people's activities working against the natural cycle.

Ecological Succession

The ecosystems of today have evolved along with the plants, and animals that are a part of them. In order to survive every species must be successful at obtaining the necessary energy and materials. Each species in turn serves as an energy and material source directly or individually for other organisms.

This has led through evolutionary time to a whole series of predator-prey interactions and feedback adjustments. As prey numbers increase, the numbers of predators will also increase. If prey numbers decline, the numbers of predators will decline and the prey population will begin to recover and build up in numbers again.

It can be inferred from the decreasing availability of energy along the food chain that this is a significant limiting resource. Other resources can also limit the numbers of organisms, e.g. moisture, temperature, suitable place in which to live, etc. As one or another limit is approached competition increases and the less efficient organisms will die. This forms the basis of evolutionary change for both organisms and ecosystems.

In addition to being modified through evolutionary changes, ecosystems are continually undergoing changes of another kind with the replacement of one community of organisms by another community. This is called ecological succession.

Ecologists recognise two types of ecological succession - primary and secondary. Primary succession occurs in a location where no living community is presently existing. This occurs for example in areas after volcanic eruptions, as occurred following the explosion on Krakatoa Island in 1883, or on newly formed sand dunes. Secondary succession is more common and occurs when an ecosystem is removed or partially destroyed, as occurs when forests are cleared to make way for village settlement, or an area is burnt by fire. In both primary and secondary succession there is a relatively orderly sequence of stages of development resulting in an ecosystem that is more stable than those preceding it.

In the tropics, the sequence of succession can be rapid because of the rich abundance of life available for change. On Krakatoa, the cave rock was first colonised by a spider wafted in on the wind. Air-borne algae soon spread over the rock providing a base on which spores of mosses and ferns as well as seeds of a few flowering plants could germinate. As the volcanic material was broken down, and organic matter added by the early colonizers less hardy plants were able to become established. Orchids were soon able to find a suitable habitat. In time, seeds of forest trees, e.g. Barringtonia and Casuarina, along with coconuts arrived by sea and began to get established. These were able to support a range of birds and insects, which in turn carried seeds of figs and other plants. Within 50 years a forest was growing strongly and thousands of organisms had settled.

The major changes of succession at a place like Krakatoa were:

Cave-rock → algae, lichens, mosses → ferns, flowers & plants → sugar cane, small trees → coconut trees, tropical forest trees.

Each stage, in turn, was able to support a greater array of other organisms as a result of the changes.

Succession occurs because organisms, by their very presence, change local conditions. As a result of these changes, e.g. increased organic matter, greater moisture, lower temperature, etc., other organisms can get established. The earlier ones must either adapt to the new conditions they helped create or die out.

Stages in succession can sometimes be seen along the coasts, as an observer moves inland from the sea's edge, and again when the tall vegetation is cleared by fire or hurricane winds, and also plants invade the relatively open space prior to the re-establishment of the dominant trees. It is on the ability of nature to recover from such changes that much of the well-being of mankind depends.

Suggested Student Activities

(1) By visiting a beach, a recently cleared area or a burnt area, try and identify stages in the ecological succession for that area.

(2) On a field trip construct a food web for a small natural area. Compare it with a food web constructed around a village.

(3) Some foresters maintain that mature trees, which are not harvested, but left to age, eventually die and rot where they grow, are wasted resources. Evaluate this idea in relation to the flow of nutrients and the structure of ecosystems.

(4) Should we preserve all species somewhere in their natural habitat? Does this include the tiger, crocodile, snake and other potentially dangerous species? How much land should be reserved for them?

(5) Find out if there are any native reserves or national parks in your area. Are the ecosystems within continuing unchanged, or is the impact of tourism altering them? Should this continue? Can it be prevented? What social and economic pressures sustain it?

(6) Take your favourite tree, or animal, and construct a foodweb with it at the centre. Make a poster displaying what you have found out about its place in the ecosystem.

(7) Establish your own aquarium. What does it have to contain in addition to water and fish?

(8) Take photographs or drawings of the beaks of a number of birds. Explain how each beak is an adaptation that enables the bird to be part of an ecosystem.

(9) Examine the seeds of a variety of plants and work out how they become dispersed. How does this help the functioning of a natural ecosystem?

(10) Consider the total oxygen requirement of a community. To balance the oxygen-carbon dioxide cycle during an average year (in the temperate zone) a leafy park the size of approximately 2,700 hectares is needed for 15,000 city-dwellers. How much area is devoted to parks in the city nearest you?

A 1.3 RESOURCES

The term 'resources' has been used with a variety of meanings by different people. There is therefore no widely acceptable definition as yet. In practice, however, something becomes a resource to satisfy people's wants. These can be both biological (e.g. food, water, shelter) and cultural (e.g. culturally prized items like shells, cattle, cars, or a house in the right locality).

Basic biological needs are relatively easily satisfied, e.g. water to satisfy thirst, but in time, and given the opportunity many people would prefer tea, coffee, wine, cider or something else other than just water. On the other hand people's cultural wants are highly varied, but in general they can all be related to the available technology as well as personal aspirations. With developing technology and many rapid changes in personal whims and choices, what is desired, i.e. what is considered to be a resource, also changes. For example, a thatched roof may be adequate protection from the climate, but a person's preference for a corrugated iron roof changes the desired resource from palm leaves to metal. Such a change is even more desired if is it thought that the possession of a such a 'modern' roof was socially desired or a mark of status.

Resources are therefore created both by technology and people's organisational ability to achieve any desired goal. Accordingly, a useful definition of a resource is that it is an attribute of the biophysical environment assessed by people to be of value in satisfying their needs or wants. It need not be just a physical object. For example, many people in the developed countries are coming to regard the peace and quietness of a location, away from industry and the noise of machines and aircraft, as a most desirable resource, worth protecting.

Classifying Resources

Resources have been classified in a number of ways. For example, one can divide them into two groups; those which are transportable (fuels, water, etc.) and those which are not (e.g. wildlife, forests). Another widely used classification scheme is that of renewable and non-renewable. Renewable resources can theoretically last forever. However such a class contains resources as different as fish and solar energy; the former may be a renewable resource depending on man's management of it, whereas it is difficult to imagine man effectively interfering with solar energy, tides and the wind. Consequently resources can be divided into three classes:

(i) inexhaustible resources; those whose availability is endless (in relation to human time spans) though they may be affected by man's action in some instances. e.g. solar energy, tidal energy, wind (i.e. their supply is independent of man's actions) air, water (the quality of which can be affected by man's actions.

(ii) renewable resources: those which can be renewed and replenished by natural processes but which can be depleted, sustained or increased by man's management of them. e.g. soil, forests, fish, wildlife.

(iii) irreplaceable resources: those which can be totally used up or at least depleted to such an extent that further recovery is too expensive (e.g. coal, oil natural gas, nuclear fuels). Some of course may be capable of re-use (e.g. most metals, some building materials).

The Supply of Material Resources

The material resources of a society include a considerable assortment of everything under the sun, ranging from precious metals to building materials such as sand and gravel, along with fuels and commodities like salt. Depending on the value placed on a particular material, to fulfil a biological or cultural demand, it may be obtained locally, e.g. sand and gravel, or it may be obtained only through world trade, e.g. aluminium, chromium and tin.

Many developing societies are unable to afford many material resources and are therefore dependent on what they can obtain from within their own nation or state. On the other hand, no developed society is self-sufficient in all the mineral resources of which it makes use. A few are like Australia which only has to purchase some resources, most are like the U.S.A., which enjoy a large amount (see table), while a number like Japan and Holland are dependent on outside sources for virtually all of their requirements.

The possession of a desirable material resource by a developing country does not automatically confer a high level of income from world trade in it. The income is dependent on the price other countries are prepared to pay for it, and the cost of transporting it to where it is wanted. An increase in the price charged for it could well result in the purchasing countries seeking an altenative source, or even a substitue resource for it. Thus the U.S.A. imports considerable quantities of certain key minerals, even though it has enough known reserves to meet demand for several decades, because they are cheaper (see table).

Are We Running Out?

The future availability of resources is an important question. Which resources are scarce and which are abundant? For the inexhaustible resources there is no significant problem concerning their availability, only the question of how they can best be harnessed for people's use. Those which are renewable can provide a sustainable yield provided management of them is done carefully. This is very much a social or environmental problem rather than a scientific one.

It is the ongoing availability of the irreplaceable resources that is of most concern when it is suggested that mankind could be running out of resources. A number of predictions made over the decade or so would want to infer that either in 15 years or so, or at least by the end of the century many resources will have been exhausted. Such statements are frequently based on a misunderstanding of what is meant by reserves.

The term reserves refers to resources whose location is actually known (i.e. proven reserves) having been determined by various technological means, as well as reserves the existence of which have been

Projected world reserves of selected metals.

Resource	Static Index (Years)*	Exponential Index (Years)+	Exponential Index Calculated Using 5 Times Known Reserves++(Years)	U.S. Consumption as Percentage of World Total	Percentage of Requirements imported by the U.S. of Selected Key Minerals
Aluminium	100	31	55	42	85
Chromium	420	95	154	19	100
Cobalt	110	60	148	32	---
Copper	36	21	48	33	39
Gold	11	9	29	26	---
Iron	240	93	173	28	30
Lead	26	21	64	25	57
Manganese	97	46	94	14	95
Mercury	13	13	41	24	---
Molybdenum	79	34	65	40	---
Nickel	150	53	96	38	90
Platinum	130	47	85	31	---
Silver	16	13	42	26	---
Tin	17	15	61	24	100
Tungsten	40	28	72	22	40
Zinc	23	18	50	26	59

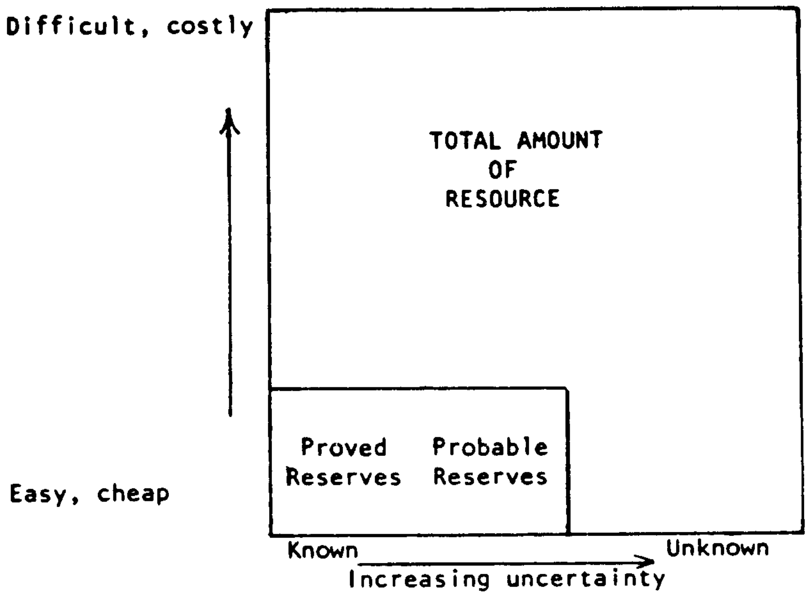
NOTES: *Static Index refers to the number of years reserves will last to 80 percent depletion with consumption growing at current rates.

+Exponential Index refers to the number of years reserves will last to 80 percent depletion with consumption increasing at 2.5 percent per annum.

++Exponential Index refers to the number of years a fivefold increase in known reserves will last to 80 percent depletion with consumption increasing at 2.5 percent per annum.

SOURCE: U.S. Bureau of Mines, 1970

reasonably inferred on the basis of geological or other suitable evidence (i.e. probable reserves). However, the availibility of such reserves is dependent on two significant factors: the available technology to get the resource, and the cost of doing so. As the problems of gaining access to the fossil fuels and various other materials are overcome, so then the amount of proven and probable reserves increases. In the same way, should there be a technological or other development which decreases the cost of gaining access so the amount that can be obtained increases. This is because no one is prepared to spend more getting some resource than he or she is going to be paid for it. The situation is illustrated in the accompanying figure.



Some resources for example gold in sea water, are present in huge quantities but the concentration is so low, i.e. it is a low grade source, that at present no one is prepared to spend the time and effort required to extract it. Resources therefore strictly do not run out, i.e. the law of conservation of matter holds, rather they become dispersed, diluted or so inaccessible that they are not recoverable, at the present time. Such a situation adds a degree of uncertainty to predicting the availability of any such resource. This is being overcome to some extent by including along with estimates of reserves, the situation if five times the known reserves became available (see table).

The present situation in regard to many material resources is that the developed countries have found numerous ways of converting comparatively high concentrations of substances into a fairly diffused state. It has been with the growing recognition of this state of affairs that more effort has recently been made in developing ways of reusing and recycling such substances. As the author Arthur C. Clarke has remarked: "solid wastes are only raw materials we're too stupid to use". This then is one of the challenges facing science and technology in the rest of this century, to devise better ways of handling some of our resources.

Suggested Student Activities

(1) Make a list of the resources you have used in the last hour (or day). Which are you prepared to do without?

(2) Visit a rubbish dump and identify the "raw materials we've too stupid to use". After your visit, debate whether you agree with Clarke's statement or not. What uses do you suggest for the "wastes". Why is this not being done already?

(3) Get a list of the materials imported into your country, and identify their uses. Will you ever run out of them? What happens then?

(4) Can you identify something which is not presently regarded as a resource but might be sometime in the future?

(5) Should such resources as those found at the bottom of the sea, belong to everybody, nobody or only those with the technology to retrieve them?

A 1.4 Food Production: Traditional versus Modern Agricultural

Food production demonstrates, more clearly than other activities, people's dependence on the natural environment. Although "artificial" foods have been synthesised for use by astronauts, the vast majority of the world's population depends on the food produced by farmers and fruit growers for its continued existence.

One of the most significant features of world history over the past 100 years has been the increased food production achieved in the so-called "developed" countries. Attempts have been made in recent years through the green revolution to increase production in other countries too. However, there are now doubts which suggest that modern methods of food production cannot be sustained indefinitely. This can be better understood by comparing traditional forms of agriculture with modern methods.

Traditional or subsistence agriculture is characterised by a low energy input, with power and labour coming from people and their domesticated animals, a low fertilizer input, and a wide range of crop varieties giving relatively low yields. For example, the Tsembaga, a New Guina group, grow garden crops in a section of tropical rain forest. With a population density of 25 persons per square kilometre (or a food productivity density of 38 per square kilometre when only arable land is considered), they cultivate up to thirty-six species of edible plants, and are able to obtain an energy yeild of about 16 for each unit of energy (work) they do. This is achieved without the aid of artificial fertilisers and pesticides.

Modern agriculture in a place like Australia for example employs very few people (about 5 per cent of the total population), requires considerable input of energy in the form of fossil fuels to power farm machines, transportation, factories and the means of distribution, raises a very numerous range of crops, and uses considerable quantities of artificial fertilizers and pesticides. Recent calculations indicate that for each unit of food energy that gets to the table to be eaten, at least five units of fossil fuel energy have had to be used.

On the energy question alone, to feed the entire world using the same modern agriculture practices, would require all the world's oil reserves, and these would be totally consumed within 20 years.

Modern industrial agriculture does not yet use solar energy any more efficiently than unindustrialised agriculture. Instead, it merely supplements the solar energy with considerable inputs of fossil fuel energy to increase the total yield. Such high yields are required to feed the many non-farmers as well as be available for export. However, as the cost of fossil fuels rises, so too will the price of such food being exported, making it less available in developing countries where it is most needed.

Energy consumption is not the only problem. Modern agriculture has brought problems of environmental pollution, resource depletion and greater degrees of social-dependence as well.

One of the more obvious forms of environmental pollution has been that of eutrophication. In some places, initially high inputs of nitrogenous fertiliser, required to increase crop yields, had lead to some of it ending up in bodies of water and stimulating the growth of aquatic plants. This in turn has led to a change in the ecology of the lake or dam holding that water, creating biological problems therein and affecting fish yields and the normal functioning of the ecosystem. This problem can, in time, be overcome by changes in fertiliser practice, but other problems are not so easily solved.

The practice of irrigation in many places, including India and Australia, has led to salinity problems which in turn require changes in investment, and therefore in social arrangements and political goals as well. An environmental problem can quickly become a social and political one, all of which require time and effort.

The most significant resource depletion problem is of course fossil fuels. Although production methods like those used by the Tsembaga are very efficient, they do not produce a significant surplus. In developed countries the agricultural component is efficient and produces more food calories than it consumes. Most energy in the process of food growing, processing, distribution and consumption is in fact used in getting the food from the farmer to the consumer. For example, to drive a car to the store and back uses half as much energy as required to produce a loaf of bread, and twice as much energy as required to grow the wheat. More than half the total amount of energy used to produce a meal is consumed using a refrigerator to store it, and a stove to cook it. Thus, countries which look to such sophisticated developments in the near future need to look also at their source of energy for such appliances.

To maintain the present industrialised food production system requires a high degree of social co-ordination. Strikes, stoppages, and communication breakdowns, whether created by sickness, union decisions or local wars anywhere in the world can threaten supplies of oil, fertiliser, machinery, spare parts and shipping movements, each of which in turn can adversely affect food production. Such interdependence can be easily strained.

INCREASING FOOD PRODUCTION AND THE ENVIRONMENTAL EFFECTS

A number of developing countries have sought to produce their own food surplus by introducing higher-yeilding varieties of crops such as wheat and rice. Countries such as India, Pakistan, the Philippines and Thailand initially recorded dramatic increases in crop yields. More recent events, however, have drawn attention to the energy, fertiliser and water resources needed to sustain such yields, as well as the changes in social structures, including storage and handling facilities and more roads and quicker means of transport required to take advantage of it.

In addition to the so-called green revolution, an increase in food production has been attempted through increasing the yields on present farms, increasing the amount of land under cultivation, catching more fish and other marine foodstuffs from the sea, eating more vegetables at the expense of animal products and devising new foods. While it is scientifically and technologically possible to do all this, consideration must be given to the environmental effects of doing so.

According to Miller (page 177) the major environmental effects of food production are as follows:

> "In developing nations the major environmental problems are loss of forests, overgrazing, loss of soil fertility in tropical areas, soil erosion, salinization and waterlogging of irrigated soil, loss of wildlife habitats, waterborne diseases, and desertification. In the developed nations the major problems are soil erosion, loss of wildlife habitats, salinization and waterlogging of soil, overfishing, and water pollution from runoff of fertilizer, animal wastes, and pesticides. Water pollution from the runoff of fertilizers and pesticides could become a serious problem in developing nations by 2000 as they increase their use of these chemicals."

In dealing with these problems, it is obivous that there is no single solution to the problem of food production. Ultimately, the provision of sufficient food to feed the world must consist of a range of efforts to reduce population growth, grow more food with less irreplaceable energy resources, reduce food wastage, and the prevention of cropland being taken over and put to other uses e.g. ubanisation.

FOOD AND NUTRITION

The value of food is not only in the provision of energy but also in the nutrients it makes available for body growth, maintenance and repair. Food production must therefore provide sufficient energy as well as the correct quality of nutritional balance if it is to be regarded as adequate.

Knowledge of basic nutrition is important, both to appreciate the requirements of food production and to maintain one's health through adequate nourishment. Some fifty or so elements and compounds are considered to be essential for life and health in people. These nutrients fall into five categories: carbohydrates, fats, proteins, vitamins and minerals, which together with water make up the six food groups.

Fortunately, each nutrient can be found in a wide variety of foods. This means that although the nutritional requirements for human beings are basically the same throughout the world, traditional diets of various peoples can differ tremendously and still be satisfactory. Tha Masai tribe of East Africa, for example, have a diet consisting of blood from cattle, sheep or goat's meat, milk, fruit and vegetables, whereas a Pacific Islander has a diet of fish, coconuts, taro, sweet potato, tropical fruit and occasionally pork.

A balanced diet consists of an adequate supply of foods which contain the range of nutrients essential for life and health. This is because each nutrient performs some particular function or functions, e.g. providing energy, repairing old or worn body tissue, or maintaining the basic physiological processes. The functioning and availability of the range of essential nutrients can be appreciated by considering each of the six categories of food.

(1) Carbohydrates

These are the body's main source of energy i.e. they provide the fuel that enables the physiological processes of the body to operate. Chemically, carbohydrates are compounds consisting of carbon, oxygen and hydrogen. The major sources of carbohydrates in most diets are plant roots, cereal grains, and sweet foods.

Fruits store their carbohydrates in the form of sugar, whereas vetegables store excess carbohydrates in their roots or tubers as starch. Root crops, such as potatoes, sweet potatoes, taro and beets are an excellent source of carbohydrates. Regrettably, in some parts of the world, people eat too much carbohydrate, and as as a result soon feel satisfied such that other important nutrients are not eaten. This can result in poor health and nutrient-deficient diseases.

The digestive system converts carbohydrates into simple sugar molecules such as glucose, fructose, and galactose. Because these compounds are the source of energy for the body, many people mistakenly purchase foods containing "sugar" believing that it is a desirable food. In fact, such sugar is a complex compound, sucrose, and there is no dietary need for this substance, and growing evidence that it may be harmful. The intake of lollies, cakes, fruit bars and soft drinks as a source of energy from sucrose is unwarranted. A balanced nutritious diet makes such items unnecessary.

(2) Fats

Fats are like carbohydrates in that thev consist of carbon, oxygen and hydrogen (as well as a few other elements). They also supply energy to the body, but a fat molecule can supply more energy than a carbohydrate molecule. This is one reason why the body stores excess energy in the form of fat. Some of the fatty acids are regarded as essential, their absence causing failure of growth and reproduction, skin problems and poor digestion.

Most of the fats in a diet come from meat and milk or milk products. Liquid fats, or oils, come from a number of plants including soy beans, nuts and safflower. Fat serves as a form of insulation, conserving body heat, and is packed around the kidneys and other body organs to protect them against injury. The eyes too are lined with fat to prevent damage to them. People who are starving have hollow eyes as a result of the disappearance of this lining of fat.

(3) Proteins

Proteins are composed of amino acids, which are made up of a carboxyl or acid group (COOH) and an amino or basic group (NH_2). The significant element in proteins is nitrogen, although they also contain very small quantities of sulphur and phosphorus.

There are some twenty amino acids which are commonly found in proteins, and the body cells use them as building blocks to construct many complex substances that make up the human body. Many of the amino acids required by people can be synthesised from the food taken in. However, people, particularly as children, require some nine or ten amino acids to be included in their diet because they cannot be systhesised. These are called the essential amino acids.

The acquisition of the essential amino acids is relatively easy when animal protein is included in the diet because of the chemical similarity between people and animals. Examples of animal protein include meat, fish, poultry, eggs, milk and cheese. The essential amino acids can also be obtained by eating cereals, fruits and vetetables. However, the proportions of the essential amino acids in plant protein differ considerably from that required by the body. It is necessary therefore, for people on a vegetarian diet to consume a variety of foods and in relatively large amounts so as to acquire enough of the essential amino acids.

Amino acids, unlike carbohydrates and fats cannot be stored in the body for future use. Proteins that cannot be used by the body are excreted, so it is necessary to have a daily intake of protein to maintain good health. In fact, more than 20 per cent of the body consists of protein in the form of red blood cells, enzymes, muscle, nerve fibres, eyeballs, skin and other tissues. Insufficient protein intake threatens the survival of the human body.

(4) Minerals

Although minerals only account for about 5 per cent of total body weight, they are vital for normal growth and development, as well as for the regulation of the body's physiological processes. A number of minerals have been found to be essential in human nutrition. These include calcium, phosphorus, iron, sodium, zinc, copper, potassium, sulphur, manganese, magnesium, cobalt, iodine, fluorine and chlorine. Ongoing research might well add to the list.

The common sources and functions of five examples of minerals is given in the following table:

Mineral	Sources	Functions	Deficiency Problems
Calcium	Leafy green vegetables, milk, cheese	Essential for blood clotting, nerve functioning, strong bones and teeth	Rickets, stunted growth, weak bones, poor teeth, nerve irritability such as cramp & twitching
Iron	Shellfish, liver, meat, eggs, chicken, peas (legumes) dried fruits	Required to make haemoglobin, and enzymes used in cell respiration	Iron deficiency anaemia
Iodine	Shellfish, sea foods	Essential in functioning of thyroid gland	Goitre, reduced metabolism
Phosphorus	Whole grain cereals (wheat, rice), liver, meat, beans, milk, soy beans	Essential for cell functioning, bones, teeth, and making enzymes	Rickets, weak bones, poor teeth, stunted growth, weakness, lack of weight
Copper	Shellfish, liver, chicken, legumes, meat, potatoes	Essential for haemoglobin, and the metabolism of fat.	Anaemia

(5) Vitamins

Vitamins are organic compounds that are found in very small quantities in foods. They are essential for the maintenance and growth of the body. They function as catalysts with enzymes in the chemical processes associated with carbohydrates, fats and proteins. The body cannot synthesise most vitamins, so they must be obtained from food. Each has a different function, and for the body to work effectively all must be available.

A normal individual who eats a variety of cooked and raw foods should nave no difficulty in obtaining the necessary amounts of vitamins. The absence of vitamins produces a range of so-called deficiency diseases. For example, a disease called scurby, which affects the blood system is cured by eating citrus fruits rich in vitamin C. A painful nerve disease, beri-beri, results from the absence of vitamin B_1 and is overcome by eating more fresh meat and vegetables.

From a nutritional point of view, the most important vitamins are vitamins A, C, D, and three of the B-complex vitamins - thiamine, riboflavin and niacin. Their common sources and functions are given in the following table:

Vitamin		B_1 or (B), (thiamine)	B_2 or (G) (riboflavin)	Niacin	B_6 (pyridoxine)	B_{12} (cyanoco-balamin)	C (ascorbic acid)	D	E	K
PRINCIPAL SOURCES	Milk, eggs, butter, green leafy and yellow vegetables, fish liver oils, liver	Meat (pork and liver), nuts, egg yolks, potatoes, most vegetables, legumes, yeast, whole grains	Milk, cheese, beef muscle, egg white, liver, organ meats	Liver, organ meats, yeast, peanuts, wheat germ	Fish, vegetables, molasses, yeast, liver, whole grains	Liver, beef, pork, organ, meats, eggs, milk	Citrus fruits, tomatoes, potatoes, green peppers, cabbage	Sunlight, butter, eggs, milk, fish liver oils	Vegetable oils, lettuce, eggs, cereal products, wheat germ	Eggs, liver, leafy green vegetables, tomatoes
FUNCTIONS	Creates healthy skin, necessary for tooth structure, growth, and night vision	Necessary for normal nerve function and carbohydrate metabolism, promotes growth	Essential for cell metabolism, promotes general health, good growth	Essential for metabolism, normal skin	Essential for amino acid metabolism and functioning of cells	Essential for production of red blood cells, growth, and nerve functioning	Necessary for healthy teeth, gums, bones, blood vessels, essential for cellular metabolism	Essential for metabolism of calcium and phosphorus, normal bone and tooth development	Not known	Essential for blood clotting
RESULT OF DEFICIENCY	Dry skin, poor teeth and gums, slow growth, night blindness, lack of tears in eyes	Loss of appetite, slow growth, improper digestion of carbohydrates, poor nerve function, beriberi (exhaustion, paralysis, heart disease)	Sensitivity to light, anemia, inflamed lips, weakness	Pellagra, skin irritation, rash, inflammation of tongue, digestive disturbances, diarrhea, nervous disturbances	Skin lesions, nerve inflammation, anemia	Pernicious anemia, retarded growth, disorders of nervous system	Scurvy, poor teeth, weak bones, bleeding gums, easy bruising	Rickets, badly formed tooth and bone structure, soft bones	Abnormal fat deposits in muscles	Slow blood clotting, anemia

(6) Water

Although not a nutrient itself, water is essential for life. Some 62 per cent of the human body is composed of it, and it is important in allowing the physiological processes of the body to work.

The water in the body is the medium for all the chemical reactions which take place. It enables the digestive system to break down the foods that are eaten into smaller molecules, and then makes it possible for the cells of the body to construct the necessary tissues from them. Water is also involved in the conduction of nerve impulses, the maintenance of a stable temperature, the flow of blood and the excretion of waste products.

Although fruits and vegetables contain water, it is generally necessary to drink more to maintain a healthy body.

A 1.5 Pollution

What is Pollution?

According to the laws of conservation of matter and of energy, neither matter nor energy can be destroyed, only changed from one form to another. From this, it follows that anything, including heat, must go somewhere. It is inevitable therefore that people will pollute, just because they exist. The problem is not so much one of eliminating pollution, but controlling it.

But what is pollution? Defined simply, it is the unfavourable alteration of people's environment as a result of human actions. Such a definition however is of limited usefulness. For example, it does not make clear what is an unfavourable alteration to the environment. Any man-made alteration probably has unfavourable effects according to some people, and favourable effects in the opinion of others, particularly if they benefit from the activity that causes the pollution. What is pollution is therefore a subjective assessment, even when information has been scientifically obtained.

There are two basic types of pollution produced by human activities. The first of these occurs when what is produced or released is not found naturally in the environment. This occurs with the production and use of synthetic pesticides, polychlorinated biphenyls (PCB's), herbicides, nerve gases, etc. The other type of pollution occurs when substances are produced in such quantities or released in such locations as to be disruptive to the functioning of the natural environment. This occurs with the production of fertilisers, disrupting natural cycles for example, or the spillage of oil in the marine environment.

In most instances of pollution, technology will be necessary to reduce the problems produced, but such an approach to pollution control is only short-term. The long-term solution to pollution problems will involve changes to new sources of energy, new social, economic and political arrangements, as well as population control.

To understand some of the possible effects of various forms of pollutants it is necessary to understand the following characteristics of natural environmental systems.

(1) Threshold Levels

Living organisms function with a certain range of conditions. Once these conditions have been exceeded in some way then their only response is to cease to function. However, prior to reaching that critical or threshold level, they are able to respond in other ways, e.g. move away from the polluting agent, hibernate or aestivate, or adapt by changing their feeding habits, etc.

In the case of pollutants, some have a threshold level which, once exceeded, produces harmful effects. These include such pollutants as organic wastes, phosphates, nitrates and excess soil additives, all of which can initially, in low concentrations, stimulate plant and animal growth, but in excess quantities adversely effect the organisms and the ecosystems of which they are members.

However, some pollutants don't have (or at least don't appear to have) a threshold level, being lethal in extremely low concentrations. Such pollutants include the heavy metals, such as mercury and cadmium (and possibly others), as well as some forms of radiation. The very toxicity of such substances makes it difficult to actually measure a low enough value beneath which they are safe. This aspect is significant, for example in disucssions about exposure to low radiation levels.

Because living organisms vary with quite different life-cycles, it is possible for the threshold level to be different too. Thus some organisms are more tolerant of some pollutants than others, while those that are sensitive can serve as indicators to the presence of pollutants as occurs with lichens, many of which respond adversely to air pollution.

(2) Synergy

A frequently overlooked aspect of pollution is the effect of two or more pollutants occurring simultaneously. Smog for example, is an atmospheric condition produced by the interaction of oxidants, and hydrocarbons coming out of the exhaust of cars. Smog pollution is more damaging than the effects of its separate constituents. This is an example of synergy.

Science has progressed through the careful use of controlled experiments where the operation of one factor is compared with a 'control' in which all other factors are the same. To assess the environmental impact of new developmental proposals it is necessary to consider the effect of two or more factors (or pollutants) operating at once. For example, when heat is discharged into a body of water, the rise in temperature could be advantageous to most organisms. However, if a pesticide is present in the water too, there is an increased sensitivity to it, i.e. a lower threshold level for it under the new conditions.

Of course, it is possible that the effect of two (or more) pollutants to some extent nullify each other as happens when water-soluble cyanides occur in water containing acid as well. The total effect of cyanide is reduced by the acidic reactions which produce hydrogen cyanide gas that is lost to the air. Either way, the phenomenon of synergy is an important aspect of the possible effects of pollutants on living things and ecosystems.

(3) Persistence and Biological Magnification

A significant attribute of a pollutant is its persistence or degradability. In the case of pesticides e.g. DDT, a desirable property is its high degree of persistence, such that mosquitoes and other pests would be more likely to come into contact with it. However, persistent pollutants by their very nature are also more likely to come into contact with human beings with potentially disastrous results.

Those pollutants which are easily broken down by natural mechanisms pose less of a threat than those which are nonbiodegradable. The only form of control possible with such pollutants is their removal by particular control measures or the prevention of their entry into the natural environment in the first place. Naturally, such requirements are expensive and have to be weighed against any of their their advantages.

In nature, it has been shown that a number of chemicals which have a high degree of persistence can actually be concentrated, or magnified, as they move up a food chain. The most quoted example is that of DDT which can occur in very low concentrates in water. If taken in by zooplankton it can be concentrated some 10,000 times, and again in small fish and large fish, until the concentration in fish-eating birds is a million or more times greater than it was in water. This biological magnification can result in the poisoning of non-intended or non-target wildlife causing disruption to the whole food web in the ecosystem. This phenomenon has resulted in the spread of certain chemicals throughout the whole biosphere, as is shown by the occurrence of DDT in the tissues of penguins.

Commencing Pollution Control

The long-term control of pollution is more of a social, economic and political problem than a scientific one. However, two basic steps need to be taken initially if pollution control is to be effective. The first of these is monitoring. If pollution is to be controlled it first has to be detected. For this, scientists are presently hard at work devising newer and better ways of detecting various substances at ever lower concentrations. In this search they have turned to the microscopic examination of such tissues as hair, nail clippings and egg shells, as well as finding out which organisms are more sensitive than others, e.g. lichens in relation to air pollution, and various insect nymphs in relation to water pollution. This aspect of scientific research is both interesting and of world-wide importance.

The second step required in pollution control is the setting of standards. For this many measurements have to be taken, and compared with results from other tests in order to establish adequate guides. These can then serve as the basis for legislation which can permit or forbid a degree of pollution which is thought can be tolerated by the natural ecosystem without undue disruption. Such an approach acknowledges that people pollute, but starts to set the limits within which we can live. The process by which standards are set is not a purely scientific one, but is nevertheless one in which scientists with their experience and expertise must be involved.

Suggested Student Activities

(1) Visit a creek, river, or some location where effluent is being discharged. Can you identify any effects resulting from it?

(2) How much air do you personally require during a 24-hour period? How much of this can you afford to be polluted with:
   - (i) additional oxygen
   - (ii) additional carbon-dioxide
   - (iii) lead
   - (iv) asbestos

(3) Can we evolve lungs that will be resistant to air pollution? Why or why not?

(4) What is meant by synergy? Can you find examples in your local environment?

(5) Can we anticipate environmental problems brought about by technology? If not, how can we best proceed with the introduction of new technologies?

A 1.6 Human Population

Growth and Control of Human Population

In recent years, alarm has been expressed concerning the possible impact of the continued growth of human populations on the environment. Such concern has arisen recently because it has only been in the last few decades that world population growth has risen dramatically. Halfway through the nineteenth century, the world population has been estimated to have been one billion people. It took all of three million years or so of previous human history to reach that number, whereas, by 1930, only eighty years later, it had doubled to reach two billion. If that was not enough, during 1976 the world population had grown to four billion, with estimates of eight billion occurring soon after the year 2000.

Such growth indicates not only that the number of people is increasing but also that the rate of increase in the number of people is also increasing. The basic problem is: Can the natural environment support such large numbers of people with adequate food, clean water and shelter? In a developed country like the U.S.A., every person in a lifetime uses approximately 45,000 kilograms of food, and nearly 100,000 cubic metres of water. Such high figures relate to a very wasteful life-style, but many other people in the world would like to have the same standard of living! If everyone, by some miracle, was to achieve such a standard, there would obviously not be enough resources without irreparable damage to the environment. More than that, with continuing rapid population growth, it would be impossible to provide adequately for the world's new-comers.

The rapid growth of human population can only be temporary. In time, it must cease to grow, either because the natural environment has been so altered that it can no longer support the larger population, with increased famines and outbreaks of disease, or because people themselves have become sufficiently aware of the problem to favour social measures which strictly limit further increases.

The relevant environmental question is therefore not whether the human population will or will not stop increasing but what physical and social conditions of life will prevail, when it does? To answer such a question it is necessary to first discuss the major factors relating to changes in the size of the human population.

Birth Rate and Death Rate

The change in a population is determined by the difference in birth rate and death rate. When the birth rate exceeds the death rate, there is an increase; when the death rate exceeds the birth rate there is a decrease in the size of the population. The birth rate or death rate is the number of births and deaths per 1,000 people in the population.

i.e., $$\text{birth rate} = \frac{\text{No. Births for one year}}{\text{population}} \times 1{,}000$$

The change in population is frequently expressed on a percentage. If this is positive there is growth, if negative there is a decline, and it can be obtained by:

$$\text{percentage annual population change rate} = \frac{\text{birth rate} - \text{death rate}}{10}$$

For example, if a country has a population of 259 million, and during that year, there were approximately 7 million births and 2 million deaths:

$$\text{birth rate} = \frac{7 \text{ million}}{259 \text{ million}} \times 1000 = 27$$

$$\text{death rate} = \frac{2 \text{ million}}{259 \text{ million}} \times 1000 = 8$$

$$\text{\% population change rate} = \frac{27 - 8}{10} = + 1.9 + \%$$

i.e., an annual growth rate of 1.9%

Change in population depends not on whether the birth rate and death rate is high or low, but on the difference between them. There is therefore no significant population change if, with a high birth rate, these is a correspondingly high death rate. On the other hand there is still growth if there is a low birth rate, and an even lower death rate.

Fertility Rate

In addition to birth rate and death rate, another important factor associated with population change is fertility rate. This is a measure of the number of live births that occur per woman. In considering population change, it is more useful to know the number of births per 1000 women per year than the number of births for any particular woman. Of course young girls and very old women are unable to have children, so the fertility rate only applies to women in the reproductive age group. This is generally taken to be women between the ages of 15 and 45 years. The feritlity rate in developed countries is of the order of 60-80, whereas in most developing countries it is much higher, up to 150 or more.

For predicting future population changes, use is made of the total fertility rate, which is the average number of children a woman will have during her reproductive period. In recent years many developed countries have experienced a drop in total fertility rate from about 4 children per woman to less than 2, although in places like Australia, there are signs that this has increased slightly recently. For the world, it has been reported that the total fertility rate in recent years has been nearly 5 children per woman. If the world is to reach the situation where population growth is zero, then the total fertility rate would need to average about 2.5. The longer it takes to reach that figure, the larger will be the world's total population, and the greater the demand for basic resources.

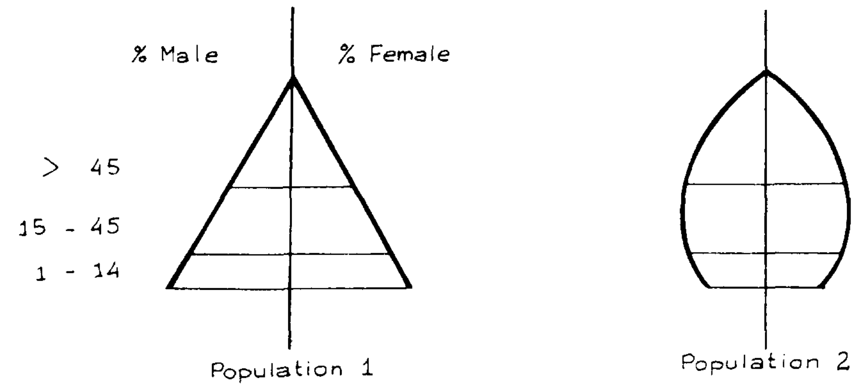
Marriage Age

Another significant factor influencing population change is the age at which women marry. It has been observed that the woman who marries at a younger age tends to have more children than those who marry later in life. In some societies, for example, China, in recent years, social pressure has been used to encourage later marriages in the expectation that the fertility rate can be expected to decrease.

Age Structure

The future growth or decline of any population is related to the age distribution or age structure of that population. It is measured by the number or better the percentage of persons at each age level in that population. Of special significance is the number, or percentage of women of child-bearing age.

Compare two populations with different age structures:



Population 1 has a high percentage of women of child-bearing age, producing a large number of children. In time these will become of child-bearing age, and because of their large number, even with a drop in the fertility rate, the population will continue to grow. Population 2 on the other hand, has a high percentage of women of child-bearing age, but they are producing a reduced number of children. In time, with a continuing low fertility rate, the population will decline.

Recent statistics indicate that more than one third of the people of the world are under the age of 15 years. These people, already present, are now becoming the parents of the next generation, <u>but even if they have a lower fertility rate than their parents, there will be continued growth of the human population</u>.

Population Change and Overcrowding

The few factors, birth rate and death rate, fertility rate, marriage age and age structure, all relate to population change. For the most part, and particularly in recent years, all those factors have given rise to a dramatic population increase. Symptomatic of that increase has been the overcrowding of cities. This is one possible consequence of population growth, but is just as much a product of social policy and technological change.

Dramatic scenes of densely populated cities have caused some people to conclude that the world is overpopulated. On the other hand, some church leaders and politicians in sparsely populated countries like Australia and Canada deride any idea that population growth needs to be controlled because of the apparent availability of abundant living space. Overcrowding, and its opposite vaste open spaces, relate not so much to population change as population distribution and density.

Population distribution is an indication of the extent to which people are scattered over a region or country. Some parts of a country for example, may be uninhabited because of climate conditions, e.g. deserts or high mountains, thereby restricitng the population to other areas. This can be important when considering the well-being of a country, because two countries of approximately the same size and population may vary in that one has more limited distribution of people than the other, giving rise to quite different living conditions. Such a situation is more easily understood by reference to population density.

Population density refers to the number of people per unit area, and is generally obtained by dividing the total population by the area it inhabits. The relationship between density and distribution is that the distribution is an indication as to how widely the population is spread.

Population density figures can still be misleading, particularly if they are calculated for large areas or regions. For example, taking total world population and dividing it by the total land surface area would give a figure of approximately 30 persons per square kilometre. This would appear to support a conclusion that the earth does not have a population growth crisis. Alternatively, if everyone on earth was alloted 1000 sq. cms. to stand on, the required area would be a very small island. Reference to overcrowding (or to open spaces) is no indication of population growth.

In considering population density, there is no sense in regarding the natural terrain, which includes deserts, forests, swamps, mountains, and fertile plains as being of equal value or productivity in supporting people. Consider for example, the population densities of three countries:

	Population Density in persons per sq. km. from Miller Page 115
China	89
India	190
Netherlands	340

From this it can be seen that the Netherlands has the highest population density, whereas it is India which is generally considered to be overpopulated. China, on the other hand, has the world's largest population, but is significantly lower in population density than the other two countries. These figures arise because the Netherlands is widely inhabited whereas much of India and China is sparsely populated.

A more useful measure of population density is the total population divided by the amount of food-producing land. Such a measure of population density related to food productivity can also be misleading, but is perhaps more informative than a density measure based on the amount of space per person.

Controlling Population Growth

While social changes can be introduced that reduce any problems of overcrowding, these need not bring about a control of population growth unless the few factors, birth rate and death rate, fertility rate, marriage age and age structure are altered in the proper way.

Conditions for population control i.e. zero population growth, would exist when:

(1) birth rate = death rate

or (2) fertility rate = 2.5

or (3) marriage age is high

or (4) age structure is such that the age groups are all about the same size.

A number of measures have been suggested for achieving this, including increased taxes on couples having three children or more, compulsory sterilisation after the second or third child, the introduction of licenses to reproduce and compulsory abortions. Such direct measures, although they undoubtedly would be effective, are unacceptable to most people, who prefer less direct methods, e.g. the provision of social services for the aged so that they need not depend on their children for support in their later years. However, in the absence of some form of concerted action to control population growth, it can only be expected that the western form of life style will not ever be possible for growing numbers of people, and that the availibility of basic resources in the way of food, water and shelter, let alone education and health services will be insufficient to go around.

Suggested Student Activities

(1) How would you define "over-population"?

(2) It has been said that one Swiss person consumes as much as 40 Somali people. How do you think this estimate was made? Compare your life-style with that of 3 other countries.

(3) What restrictions occur as the population and population density of an area increases. What advantages do you gain?

(4) Calculate the level rate, and annual population change rate for your area or country.

(5) Draw up an age-structure diagram for your locality. Compare it with your country, as well as neighbouring countries. Is there any need for concern now, or in the future?

(6) Visit any of the following if possible:

(i) population control clinic
(ii) family planning sessions
(iii) child welfare centre
(iv) mothers and babies welfare centre

What were your impressions?

APPENDIX 2

DEFINITIONS AND AIMS FOR ENVIRONMENTAL EDUCATION

(a) Environmental education is a way of implementing the goals of environmental protection. Environmental education is not a separate branch of science or subject of study. It should be carried out according to the principle of life-long integral education. (Proposed by the Seminar on Environmental Education, organized by the Finnish National Commission for Unesco at Jammi, 1974.)

(b) Environmental education involves teaching about value judgements and the ability to think clearly about complex problems - about the environment - which are as political, economical, and philosophical as they are technical. (Proceedings of the Organization of American States Conference on Education and the Environment in the Americas, 1971.)

(c) Constructive attitudes toward the environment, in both the philosophical and programmatical senses, have not yet become an ingredient in everybody's thinking and acting. This remains the basic objective of environmental education. (Final Report: Intergovernmental Conference of Experts on the Scientific Basis for the Rational Use and Conservation of the Resources of the Biosphere, 1968.)

(d) The educational process dealing with man's relationship with his natural and man-made surroundings, and including the relation of population, pollution, resources allocation and depletion, conservation, transportation, technology, and urban and rural planning to the total human environment. (In United States Public Law 91-516, The Environmental Education Act.)

(e) In order to enable people to enjoy good health and a high quality of life, it is vital to prevent harmful effects to human health or damage to the environment caused by pollution of air, water and soil, noise, vibration, noxious smells, etc., caused by firms and individuals. The environment includes animals and plants and their ecological systems which are closely bound to the livelihood of people. (National Anti-Pollution Law, Japan, 1969.)

(f) Environmental education and the exercise of citizenship go hand in hand; the opening up of opportunities for public participation in decision-making is the most important of all means to environmental education, which should aim at developing a critical, moral and aesthetic awareness of our surroundings. (quoted in "The Genesis of Environmental Education" by K. Wheeler in "Insights into Environmental Education" edited by G.C. Martin and K. Wheeler, Oliver and Boyd, 1975.)

(g) The aim of environmental education is to develop a world population that is aware of, and concerned about the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and prevention of new ones. (as stated in P.J. Fensham "A Report on the Belgrade Conference on Environmental Education (Canberra, 1976) p. 25.)

(h) A basic aim of environmental education is to succeed in making individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic, and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and the management of the quality of the environment.

A further bacic aim of environmental education is clearly to show the economic, political and ecological interdependence of the modern world, in which decisions and actions by the different countries can have international repercussions. Environment should, in this regard, help to develop a sense of responsibility and solidarity among countries and regions as the foundation for a new international order which will guarantee the conservation and improvement of the environment. (Final Report of the Tbilisi Intergovernmental Conference on Environmental Education, 1977.)

Environmental education is no more and no less than 'citizenship education', the development of personal commitment and social responsibility combined with a systems-centred holistic view of man in relation to nature, tied to a fundamental faith in the institutions of man and his abilities. Citizenship also means political obligation: a readiness to participate in the shaping of the community; an ability to assess, to assimilate, and where necessary challenge public policy; and a willingness to serve in the interests of others. (O'Riordan, T. Environmentalism, Pion Ltd., London, 1976, pp. 314-15.)

APPENDIX 3

DECLARATION OF THE TBILISI INTERGOVERNMENTAL CONFERENCE ON ENVIRONMENTAL EDUCATION

The Intergovernmental Conference on Environmental Education, organized by Unesco in co-operation with UNEP, convened in the City of Tbilisi reflecting the harmony and consensus achieved there, solemnly adopts the following Declaration.

In the last few decades, man has, through his power to transform his environment, wrought accelerated changes in the balance of nature. The result is frequent exposure of living species to dangers which may prove irreversible.

The Declaration of the United Nations Conference on Human Environment organized in Stockholm in 1972 proclaimed: "to defend and improve the environment for present and future generations has become an imperative goal for mankind". This undertaking urgently calls for new strategies, incorporated into development, which particularly in the developing countries is a prerequisite for any such improvement. Solidarity and equity in the relations between nations should constitute the basis of a new international order, and bring together, as soon as possible, all available resources. Education utilizing the findings of science and technology should play a leading role in creating an awareness and a better understanding of environmental problems. It must foster positive patterns of conduct towards the environment and the nations' use of their resources.

Environmental education should be provided for all ages, at all levels and in both formal and non-formal education. The mass media have a great responsibility to make their immense resources available for this educational mission. Environmental specialists as well as those whose actions and decisions can have a marked effect on the environment, should be provided in the course of their training with the necessary knowledge and skills and be given a full sense of their responsibilities in this respect.

Environmental education, properly understood, should constitute a comprehensive lifelong education, one responsive to changes in a rapidly changing world. It should prepare the individual for life through an understanding of the major problems of the contemporary world, and the provision of skills and attributes needed to play a productive role towards improving life and protecting the environment with due regard given to ethical values. By adopting a holistic approach, rooted in a broad interdisciplinary base, it recreates an overall perspective which acknowledges the fact that natural environment and man-made environment are profoundly interdependent. It helps reveal the enduring continuity which links the acts of today to the consequences for tomorrow. It demonstrates the interdependencies among national communities and the need for solidarity among all mankind.

Environmental education must look outward to the community. It should involve the individual in an active problem-solving process within the context of specific realities, and it should encourage initiative, a sense of responsibility and commitment to build a better tomorrow. By its very nature, environmental education can make a powerful contribution to the renovation of the educational process.

In order to achieve these goals, environmental education requires a number of specific actions to fill the gaps that, despite outstanding endeavours, continue to exist in our present education systems.

Accordingly, the Tbilisi Conference:

<u>Appeals</u> to Member States to include in their educational policies measures designed to introduce environmental concerns, activities and contents into their education systems, on the basis of the above objectives and characteristics;

<u>Invites</u> educational authorities to promote and intensify thinking, research and innovation in regard to environmental education;

<u>Urges</u> Member States to collaborate in this field, in particular by exchanging experiences, research findings, documentation and materials and by making their training facilities widely available to teachers and specialists from other countries; and

<u>Appeals</u>, lastly, to the international community to give generously of its aid in order to strengthen this collaboration in a field which symbolizes the need for solidarity of all peoples and may be regarded as particularly conducive to the promotion of international understanding and to the cause of peace.

GOALS, OBJECTIVES AND GUIDING PRINCIPLES OF ENVIRONMENTAL EDUCATION IN ACCORDANCE WITH RECOMMENDATION NO. 2 OF THE TBILISI CONFERENCE

1. The goals of environmental education are:

   (a) to foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas;

   (b) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;

   (c) to create new patterns of behaviour of individuals, groups and society as a whole towards the environment;

2. The categories of environmental education objectives:

   Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.

   Knowledge: to help social groups and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associate problems.

   Attitudes: to help social groups and individuals acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection.

   Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems.

   Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems.

3. Some guiding principles for environmental education:

   Environmental education should:

   - consider the environment in its totality - natural and built, technological and social (economic, political, technological, cultural-historical, moral, aesthetic);
   - be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages;
   - be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;
   - examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;
   - focus on current and potential environmental situations, while taking into account the historical perspective;
   - promote the value and necessity of local, national and international co-operation in the prevention and solution of environmental problems;
   - explicitly consider environmental aspects in plans for development and growth;
   - enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;
   - relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;
   - help learners discover the symptoms and real causes of environmental problems;
   - emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;
   - utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.

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