Environmental Issues in Secondary Education

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ABSTRACT

This paper, one of a series of study on science and technology issues, discusses the status, issues and provides recommendations for improvement of secondary school environmental education, especially in relation to natural science teaching. Therefore, the common environmental problems are discussed in order to identify environmental education needs. Environmental secondary school curricula are analyzed, and suggestions for improvements are made. Two possible approaches to introduction of environmental education into school curricula are discussed - the integral and the infusion approaches - and examples are given of different possibilities for infusing environmental topics into teaching of science. Besides the environmental education contents, examples of methodological approaches are presented, which can improve the quality of teaching. Teacher training is a critical component in both introduction and improvement of environmental education. Status and strategies of pre-service and in-service environmental teacher training are summarized, followed by an analysis of environmental curricula in teacher training. Deficiencies are identified and suggestions are listed for supplementing and/or upgrading both, the environmental content and the methodology courses for secondary school science teachers. The World Bank efforts in environmental education are summarized, with the proposal to introduce/strengthen the environmental components of the Bank educational projects in developing countries. Finally, examples of environmentally-related science curricula, teaching units and practical activities are given in 10 case studies together with a bibliography.
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FOREWORD

Environmental education has two broad purposes. The first purpose is to promote environmental literacy among citizens on matters directly affecting their daily lives, so that they can make knowledge-based, environmentally sound decisions, and can actively participate in the improvement of local, national and global environmental conditions. The second purpose is to build up the environmental scientific and technological knowledge and skills for the future workforce, and to prepare students in higher education for environmentally-related careers.

With the introduction of environmental issues in secondary school science teaching, important gains can be made in the environmental competence of the students. At the same time, the quality of science teaching itself can be upgraded by illustrating fundamental scientific concepts with important environmental processes and environmental problem solving.

Given the potential benefits, provision of quality environmental education to all children may have far-reaching consequences for the national development process, improving not only the state of the environment and the utilization of natural resources, but also of health, nutrition, family planning, agriculture, forestry, tourism and industry.

This paper is a follow-up to two earlier environmental education studies: "Environmental Education in Asian Countries," in ASTPH* (Boh, 1991), and "Environmental Education in the Central and Eastern European Countries - Problems and Prospects" (Boh and Kornhauser, 1992), supervised by PHREE and financed by EMTEN. The paper is not region specific. It focuses on the status of and issues in secondary school environmental education, discusses trends, problems, curricula, methodological approaches, teacher training and the role of the Bank in supporting environmental education in secondary schools. Based on analysis and discussion of examples and key studies, the paper provides recommendations for improvements, especially in relation to natural science teaching. Finally, it serves as a source of information, particularly for Bank staff working on secondary school, science teacher training and environmental projects.

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* ASTPH=Asia Technical Department, Human Resources Development Division.
PHREE=Population and Human Resources Department, Education and Employment Division.
EMTEN=Europe and Central Asia, and Middle East and North Africa Regions Technical Department, Environmental Division.
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EXECUTIVE SUMMARY
WITH CONCLUSIONS AND RECOMMENDATIONS

Tailoring environmental education for solving environmental problems

Some environmental problems are universal, but the most acute differ in high- and low-income economies, and in different climatic regions. Therefore, no general environmental education curriculum could be directly adopted as most appropriate for all parts of the world. There is no universal best approach for all environmental education situations, for all learners and for all countries. Environmental education programs have to refer to local conditions and should be designed to address both local and global environmental problems. Teachers must be free to select the most appropriate teaching styles, methods and techniques for any given situation.

A good environmental education program may have strong, positive and long term environmental effects, such as:

- reduction of uncontrolled population growth,
- improvement of health, especially in prevention of waterborne and other infectious diseases,
- efficient use of natural resources and materials,
- introduction of energy efficient technologies in industry and agriculture,
- energy conservation programs in building construction, traffic and households,
- reduced indoor air pollution in poor countries,
- reduced emissions of greenhouse, acid rain and ozone depletion gasses,
- source reduction of wastes (waste minimization in industry, agriculture, and in households),
- awareness of the damage associated with the incorrect use of agrochemicals,
- improvement in manufactured products durability,
- elimination of excessive packaging in industrialized countries,
- improved waste management (better collection and sorting, improved processing, safer disposal of wastes),
- conservation of natural habitats and wildlife, protection of species,
- introduction of environmentally sound policies and investments for a sustainable national development.

To achieve long-lasting effects, environmental education has to transcend the traditional memorizing of basic ecological concepts, and go beyond the simple promotion of an awareness of environmental problems. The main goals of contemporary environmental education are:
Summary of conclusions and recommendations

(1) to develop environmental scientific and technological literacy,
(2) to encourage students - future citizens - to actively search for environmentally sound solutions in their daily lives and as participants in the political system,
(3) to provide experience in responsible environmental decision-making.

Designing environmental education curricula and teaching methodologies

Secondary school environmental teaching has to provide a well balanced combination of:

(1) fundamental scientific knowledge necessary to understand the natural processes,
(2) applied knowledge for understanding every day life situations, and
(3) specific environmental knowledge about environmental problems and possibilities for their solution.

In addition to solid theoretical background, students need to acquire practical experiences in science-related environmental laboratory and field work, as well as skills for data gathering, evaluation of information, communication, problem-solving and decision making.

Practical activities, especially laboratory experiments, field work and excursions, are of high importance but are often neglected. Examples of cost-effective solutions prove that most of the scientific and environmental concepts can be illustrated with modest equipment and in relative simple surroundings.

Several studies show that two methods, the single subject and the infusion approaches are appropriate for the introduction of environmental education into secondary school curricula, though the infusion seem to be more common. The choice depend on the existing educational policy, curriculum time frame, existing school subjects, and teachers' qualifications. In the infusion approach, environmental concepts may be introduced through a variety of school disciplines, such as biology, chemistry, agriculture, health education, home economics, physics, mathematics, geography, history/social studies, economics, technology and engineering, safety at work, religion/ethical education, languages and arts. Environmental education as a separate school discipline (single subject approach) is sometimes introduced in specialized technical schools with relatively short science programs. Environmental education curricula should constantly be updated with new discoveries, experiences and methodological approaches. Therefore, a cooperation of teachers and educators with scientists, researchers, engineers and other specialists is essential.

Through the infusion of environmental concepts into science, traditional science teaching approaches can be enriched and become more relevant to the majority of students, who do not intend to continue their studies in a scientific direction.
Summary of conclusions and recommendations

Improving environmental teacher training

Insufficient teacher training remains the most critical constraint in the improvement of environmental teaching methodologies and in the introduction of hands-on environmental science. In each country, mechanisms need to be introduced to motivate, support and supervise environmental teacher training and the quality of environmental teaching at schools.

In most countries there are at least some basic environmental concepts in pre-service and/or in-service training of science teachers, though there are exceptions with no environmental teacher training at all. Most of the traditional curricula for training of science teachers cover the basic concepts of ecology and briefly discuss environmental problems. New environmental concepts and issues have to be brought into environmental teacher training, such as waste minimization and energy conservation concepts; new materials, technologies and agricultural practices; global environmental issues; and possible solutions and actions for solving environmental problems.

Another important deficiency in teacher training is the lack of contemporary methodological approaches to environmental education, which stresses active learning, cross-disciplinarity, adaptation to local conditions, and orientation towards understanding and solving environmental problems. In formal pre-service teacher training, environmental education can be taught as an integral course or infused into all specialized and general teacher training subjects. By infusing environmental components, the quality of existing teacher training programs can be significantly upgraded.

While there is a strong need to reform pre-service environmental teacher training, an even more urgent priority seems to be the introduction of appropriate continuing in-service environmental education, adapted to local needs and resources. As the initial priority, the environmental education competence of teacher educators at universities and teacher training colleges has to be upgraded and improved.

The World Bank role

The Bank supports a large number of environmental activities, varying from direct environmental projects and environmentally-related elements in different lending operations, to the preparation of country specific, regional or sector oriented environmental studies.

At present, most of the Bank environmental activities in developing countries focus primarily on agriculture and rural development loans, followed by energy, transportation, water and sewerage, industry and urbanization projects.
Summary of conclusions and recommendations

The possibility to introduce environmental issues into school curricula has been overlooked in most educational projects sponsored by the Bank. The direct participation of the Bank in a variety of large scale education projects in developing countries - from primary to postgraduate levels - provides a unique opportunity to promote the strengthening of environmental education. Such programs might significantly improve the environmental literacy and thus provide a long-term support to a sustainable, environmentally balanced development in borrower countries.
INTRODUCTION

Trends in teaching of science and environment

In the past, science was widely taught in schools with the primary goal and purpose to train future scientists and specialists in different branches of technology. Contemporary approaches to science teaching in most countries target a scientific literacy for all students - what every person should know and understand about science and be able to use in life.

Similarly, environmental science and technology for a long time remained specialist subjects in training of ecologists and environmental engineers. In the last two decades, accumulated environmental problems led the education planners to stimulate the introduction of environmental concepts into primary and secondary schools. At these levels, the main goal of environmental educational programs was (and still is in many cases) environmental awareness. Along with the new concepts in science teaching, a new concept of environmental education is being developed: environmental education for all students, aiming at preparing them for every-day problem solving and environmentally responsible decision-making. The motto of these efforts has been: "Think globally, act locally - start with yourself, change your habits and values, act as an environmentally conscious consumer and citizen."

An overview of environmental education problems and needs

In several countries, there is a gap between actual environmental problems and the contents of environmental education in schools.

Environmental education is often limited to traditional ecology courses, pollution monitoring and visits to national parks. Programs which would link environmental education with everyday life situations are rather rare (e.g. improving human health, energy conservation, environmentally friendly products, materials recycling, cleaner technologies, waste minimization). Little emphasis is put on global environmental issues.

Today, environmental education is expected to transcend the simple awareness of issues and should incorporate direct training for problem remediation.
Introduction

In many cases, the existing curriculum still follows the traditional ways of teaching.

Teaching methods in science are often formal and based on theoretical studies. Their descriptive character does not attract the majority of students. The emphasis is on memorizing instead of understanding environmental processes and their concepts. Higher levels of environmental teaching should develop the knowledge skills necessary to investigate and evaluate alternative solutions, make responsible decisions and act for resolving environmental problems.

Environmental education materials are often not adapted to specific local conditions.

Currently, environmental education is rarely linked with the solution of local environmental problems. Environmental education materials are often general, not reflecting local environmental problems and not preparing students for coping with them. Little emphasis is put on strengthening the individual's responsibility for improving local and global environmental conditions.

There is a need for flexible teaching units, based on interdisciplinary and problem-solving approaches, which could be adapted to local needs and linked with global environmental protection. Exchange of such materials at regional and international levels might quickly improve the situation.

Incorporation of environmental issues throughout the educational system is not systematically done.

In most educational systems, environmental issues are infused into teaching of traditional school subjects. Many authors agree that infusion is a relatively simple process to understand, but complex to accomplish. The infusion plan at each educational level has to respect the integrity of scope and sequence, otherwise the instruction cannot proceed logically across content areas. In practice, the infusion approach meets several obstacles. (1) The environmental themes are often taught as isolated facts, and the information is scattered and fragmented. (2) There is a lack of coordination of environmental topics across the school subjects. (3) Natural sciences and technology curricula often include few separate environmental teaching units, but humanity subjects usually avoid environmental issues. At the university level, priority is often given to specialized environmental courses.
Practical experiences in environmental education are often neglected.

Students cannot be expected to change their behavior and become effective and environmentally responsible citizens when only lectures and textbooks are used in the teaching-learning process.

Effective verbal forms of environmental education (student reports and seminars, interviews, role playing, simulations, panel discussions, etc.) which help to develop skills for decision-making and environmental problem solving are rarely used.

Environmental excursions to natural ecosystems, environmental centers, waste treatment plants, industry, agriculture, etc., are not given sufficient attention. Teachers are often not aware of the rich and cost-effective resources that are available in the local community.

Laboratory and field experiments tend to be "executing cookbook procedures". In teacher training a stronger guidance is needed on how to develop efficient practical environmental education teaching units, using the local natural and urban environments and the low-cost, locally-produced teaching equipment.

Teacher training in environmental issues and problem solving methods is the key to an improvement of environmental education.

In some countries with relatively short or weak teacher training programs, there is a need to introduce or upgrade the basic environmental knowledge.

Many teachers who already have received traditional environmental training are not sufficiently trained in interactive cooperative learning and problem-solving teaching methods and techniques.

Work on practical environmental problems always require a multidisciplinary approach, and thus the cooperation between teachers of different subjects. Programs for teacher training which involve an interdisciplinary group of experts from environmental research and development institutions, local industries, agriculture, forestry, health care and social sciences, need to be developed.

There are many opportunities for action-oriented approaches, e.g. for improving health conditions, energy conservation, waste minimization, introducing cleaner technologies, recycling of materials, processing of hazardous waste, and protection of species.

Short in-service training courses, commonly of one to two days' duration, which give overviews of selected environmental topics, are frequently provided but they cannot replace a systematic training in basic and applied aspects of environmental science, technology and management for sustainable development.
There is a need for guidelines for teacher training programs in environmental education at regional levels, including advice on their adaptation to local needs and their practical implementation.

However, the development of environmental education implies not only training of teachers, but also training of higher level personnel, responsible for educational direction, inspection and planning, who in practice may strongly influence the process of innovation, has turned out to be essential for the introduction of new approaches and concepts in environmental teaching.

Finally, there is a need for improving the environmental knowledge of managers, policy-makers, politicians, journalists, specialists in governmental and voluntary organizations.

Common drawbacks in the improvement of environmental education are insufficient coordination and cooperation at all levels.

A better coordination of environmental activities between subjects in each school, on national and regional levels, an accelerated exchange of successful environmental education materials and valuable teaching experiences, and a stronger cooperation of environmental specialists in different fields, might improve the quality of environmental teaching fast.

In some cases, environmental education is still considered a non-priority subject, and is not included in important assessment procedures, such as university entrance examinations.

In low income countries and in countries facing major political transitions, severe socio-cultural changes and acute economic problems, environmental issues are usually given low priority.

Unfortunately, the potentials of environmental education are often overlooked in research, planning and implementation of international environmental and health programs. For instance, comprehensive studies have been made on how malnutrition, inadequate diet and helminthic infections adversely affect the child development, health, and learning capabilities in low-income countries. Proposed solutions to this serious problem include procedures for monitoring deficiencies, and action plans for the distribution of deworming drugs and supplementary feeding to combat protein-energy malnutrition, iron, iodine and vitamin deficiencies (Levinger, 1992). Another strategy to improve health and nutrition may be launched from the opposite direction - from improved education towards better nutrition and health (Thulstrup, 1993). In this case, education on how to prevent helminthic infections, how to introduce better balanced diets and
how to improve cooking procedures to retain the nutritional value of the available food as high as possible, may become an additional component of health and nutrition projects.

Another example of overlooking the importance of environmental education is the World Development Report 1992 - Development and the Environment (The World Bank, 1992), which profoundly analyses and explains the environmental issues, and sets five environmental priorities for actions to support the development: water, air pollution, solid and hazardous wastes, land and habitat, and atmospheric changes. Environmental education, as an essential component in the implementation of any environmental program, is not among them, neither is discussed in another context in the report.

However, the World Development Report 1993 - Investing in Health, pays more attention to the importance of education in health issues, recognizing the fact that schooling affects health through changing personal habits and life-style. Educated people tend to make choices that are better for their health, and also better for the environment. The effect is even stronger when the education of women is improved. According to the study, educated women are important part of the reason for the impressive health achievements of China, Costa Rica, India's Kerala State, and Sri Lanka, despite relatively low incomes (World Bank, 1993).

Planning for the improvement of environmental education and training

When planning the improvements of environmental education, the following key questions have to be discussed and resolved:

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<td>What are the main environmental problems of the local community and the country (in addition to global environmental problems)?</td>
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<td>In this context, what is missing in the existing environmental education and training?</td>
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<td>Which parts of environmental education programs have to be changed (extended, reduced, qualitatively improved?)</td>
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<td>Which are the target groups for different activities?</td>
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<td>What are the possible formal and informal programs for different target groups?</td>
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<td>What are the existing resources and which new materials have to be developed or adapted to fulfill the needs?</td>
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<td>How can new programs be introduced into the existing educational systems?</td>
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<td>What additional training is needed for teachers and other trainers?</td>
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<td>Who will develop/adapt and finance new teaching programs: curricula, textbooks, manuals, equipment, and teacher training?</td>
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Developing an environmental curriculum

The Unesco-UNEP discussion guide on procedures for developing an environmental education curriculum, prepared as a part of a comprehensive environmental education series, recommends the following schedule for environmental education curriculum development within a country (Hungerford and Payton, 1986):

1. Organize a curriculum core development team:
   a) choose members (selected teachers, teacher coordinator, representatives of administrators),
   b) establish tasks and timelines,
   c) collect appropriate resources (e.g. curriculum materials and professional references),
   d) identify the constraints that will impinge upon the curriculum development effort and plan for resolving same.

2. Identify professional consultants who will serve as a recommendation support team (curriculum development specialists, environmental education specialists, environmental scientists, community representatives, program evaluation specialists*):
   a) establish tasks and timelines,
   b) identify liaison procedures to be used between core development and recommendation support teams

3. Develop curriculum scope and sequence:
   a) define curriculum goals,
   b) define concepts, skills and attitudes to be incorporated as objectives into the curriculum (the scope),
   c) assign objective components to appropriate grade levels and content areas (the sequence).

4. Evaluate the existing school program with respect to potential infusion of environmental education elements:
   a) identify environmental education objectives which already exist in the present curriculum,
   b) identify materials in present curriculum which could be modified to meet environmental education objectives,
   c) identify deficiencies in present curriculum where new materials must be selected or developed to complete the proposed environmental education scope and sequence.

5. Inventory and evaluate the community/regional resources available for use in the environmental education curriculum.

6. Prepare the environmental education curriculum:
   a) review and evaluate the materials which have been collected for potential adaptation or adoption,
   b) organize writing teams to adapt or develop environmental education materials needed to complete the curriculum.

7. Develop plans for both pilot and full scale implementation.

8. Develop a comprehensive evaluation program.
A more complete group of consultants outside the field would in addition include (1) scientists from natural and social sciences who can contribute new achievements from their disciplines and advise on infusion possibilities, (2) engineers from different industrial and agricultural fields, who can enrich the program with technical viewpoints, problems and proposals for solutions of environmental issues; (3) environmental lawyers and economists, who can supplement the environmental science with illustrations from every-day conflicting situations of balancing environmental and short-term economic benefits.

A good example of developing, testing and optimizing an environmentally-related science curriculum for high school students is the history of ChemCom (Chemistry in the Community - first edition ACS, 1988, second edition 1993)*. The project began in 1982. Initial materials were designed by high school teachers, piloted in the schools by a larger group of teachers, and rewritten as a result of teacher and student feedback (Ware, 1989 and 1992). The materials were then evaluated in a field test (school year 1985-86), which allowed the developers to find out practical advantages and problems of specific topics and approaches. According to Ware, 1992, the field test revealed that the greatest problem in the curriculum was the teacher acceptance of the two curriculum emphases of "everyday coping" and "science, technology, and decisions". Teachers, used to the traditional science teaching, worried about the quality of science introduced through practical issues from every day life situations.

On the basis of field test, the text was revised for the classroom evaluation by a team of chemical educators both from high school and college levels. The scientific (chemistry) content was verified by industrial and academic specialists - who, on the contrary to teachers, expressed great enthusiasm for the "everyday coping" approach.

The introduction of ChemCom was strongly accompanied by teacher training. About 250 teachers were trained as ChemCom Resource Teachers for further training of several thousands of teachers in their own communities (Ware, 1992).

* The analysis of ChemCom curriculum, with emphasis on environmental components, scientific concepts and practical activities, is given in Case Study 1.
Some environmental problems are universal, but the most acute and those with highest priority differ in high-income and low-income economies are different.

According to the World Development Report (The World Bank, 1992), the most immediate and life-threatening environmental problems facing poor countries are:

(1) unsafe drinking water,
(2) inadequate sanitation,
(3) soil depletion,
(4) indoor smoke from cooking fires and
(5) outdoor smoke from coal burning.

These problems are different from major environmental problems in highly industrialized countries, such as:

(6) high carbon dioxide emissions,
(7) depletion of stratospheric ozone,
(8) photochemical smog,
(9) acid rain and
(10) hazardous wastes.

Environment, development and environmental education

Despite progress over the past decades, more than 1 billion people still live in acute poverty and suffer from grossly inadequate access to the resources and information - education, health services, infrastructure, land, and credit. Poverty reduction requires an accelerated economic growth, which may put much pressure on the environment.

In this respect, good environmental education may prevent that mistakes of the past are not repeated. Environmentally educated societies and citizens can choose policies and investments that are better adapted to their specific environments and enable more efficient use of resources. They can adopt cleaner technologies and practices, select environmentally friendly products and introduce effective programs for waste minimization, materials recycling and conservation of natural habitats.

The World Development Report (The World Bank, 1992) states that "Without adequate environmental protection, development will be undermined; without development, environmental protection will fail".
Environmental problems and environmental education needs

It might be added that without scientifically and environmentally literate citizens, both negative consequences will occur. Only informed consumers, producers and citizens have a choice of doing the environmentally right things. If they do not understand the relevant concepts, their behavior will never be consistent (Thulstrup, 1993).

Population growth, development and the environment

By mid-century the rate of population growth in developing countries had risen as mortality decreased and life expectancy increased. World population growth peaked at 2.1 percent a year in 1965-70, the most rapid rate of increase known in history. As more countries have begun a transition toward lower fertility, population growth slowed down to 1.7 percent, but nevertheless - the world population is increasing by 93 million a year. Even with the optimistic scenario regarding population growth, the world population would more than double from current level of 5.3 billion. The World Bank (1992) estimates that the population would stabilize at about 12.5 billion around 2050; 95 percent of population growth would take place in developing countries. Most of these people will be born into poor families. Already now, more than 1 billion people live in poverty (The World Bank, 1992).

The population growth influences the environment strongly, especially since it increases (1) the demand for goods and services, (2) the need for employment and livelihoods, (3) the demand for natural resources and (4) the environmental damage (higher amount of waste, destruction of natural habitats, extinction of species, etc.).

Water problems

Industrial and agricultural water pollution

Especially in some of the middle-income countries, intensive agriculture and industries based on old technologies are still heavily polluting rivers, lakes and oceans. Major pollutants are toxic and hazardous chemicals, pesticides, heavy metals, surfactants and waste oils. Water in the Baltic sea, for example, contains strongly increased concentrations of cadmium, mercury, nickel, and over ten-times increased levels of zinc, copper, lead, cobalt, iron, PCB, hydrocarbons from oil derivatives and nutrients (Boh and Kornhauser, 1992).

Lack of drinking water and sanitation

One billion people in developing countries do not have access to clean water and 1.7 billion lack access to sanitation. According to statistics, 900 million people suffer from diarrheal diseases every year, 200 million from schistosomiasis or bilharzia and 900 million from hookworm. Cholera, typhoid and paratyphoid also continue to spread.

In Sub-Saharan Africa, for example, contaminated drinking water and poor sanitation contribute to more than 60 percent of all deaths. Out of 3 million deaths of children caused by diarrhea, 2 million lives could be saved if adequate sanitation and clean water were available (The World Bank, 1992).
A strong environmental education in combination with health care programs could substantially reduce the spread of waterborne and other infectious diseases. Several studies have proved a strong correlation between education of the population (especially education of women) and human health (World Bank, 1993).

**Water scarcity**

Globally, fresh water is abundant, but twenty-two countries already have renewable water resources less than 1,000 cubic meters per capita, which is regarded as a severe water scarcity level. Additional eighteen countries have less than 2,000 cubic meters per capita, demonstrating little in years of short rainfall (The World Bank, 1992). Most of the countries with limited renewable water resources are in the regions with the fastest population growth.

Water scarcity is becoming an increasing constraint not just in households, but on the economic activity in general. Decision-makers and water managers often have to make choices between water quantity and quality. For such decisions a deep environmental knowledge is needed. On the level of individual households and farms, environmental education for more efficient water use and water conservation strategies may be introduced.

**Air pollution**

According to the World Bank reports, in the second half of 1980s about 1.3 billion people worldwide lived in urban areas with air that did not meet the WHO standards for particulate matter (airborne dust and smoke). If emissions could be reduced to the WHO acceptable values, an estimated 300,000 to 700,000 lives could be saved each year, and many more people would be spared the suffering caused by chronic respiratory difficulties. Unfortunately, pollution by soot and smoke is still worsening in poor countries, but is improving in middle and high-income economies.

An estimated 1 billion of people live in cities with air that exceed WHO standards for sulfur dioxide. High levels of lead, primarily from vehicle emissions, have been identified as the greatest environmental danger in a number of large cities in the developing world.

For hundreds of millions of the world’s poor citizens, smoke and fumes from indoor use of biomass fuel (wood, straw, dung) pose much greater health risks than any outdoor air pollution. The health effects, especially for women and children, can be equivalent to those of smoking several packs of cigarettes a day.

In such cases environmental education can contribute to a reduction of the air pollution by encouraging the introduction of more efficient (and cleaner) heating and cooking practices (e.g. design of better cooking stoves in poor countries) and through the introduction of alternative fuels (e.g. alternative fast-growing fuel plants).

**Soil and agricultural problems**

Soil degradation is the cause of stagnating or declining yields in most of the countries, but especially on lands from which the poorest farmers attempt to wrest a living. Estimates on soil depletion suggest that in some countries this causes loss equivalent to 0.5 to 1.5 percent of the GDP per year (The World Bank, 1992). Soil erosion and desertification are the most visible and dramatic symptoms of this phenomena, but gradual degradation of agricultural soils, especially in drylands,
Environmental problems and environmental education needs

and waterlogging combined with salinization in highly irrigated areas, are also serious problems and even more widespread. Agricultural intensification (monocultures, intensive use of fertilizers and pesticides) causes increased problems in Europe, North America and Eastern Asia.

Environmental education on (1) different soil conservation strategies (contour farming, terracing, strip cropping, shelter belts, minimum-tillage), (2) improved irrigation strategies, (3) more efficient use of fertilizers, and (4) introduction of less toxic pesticides or bio-insecticides might result in a better land use and help protect the natural environments.

Natural habitats and loss of biodiversity

Some of the natural habitats, especially tropical forests, coastal and inland wetlands and coral reefs are being degraded or changed at high rates. Tropical forests, for example, have declined by one-fifth in this century. In many regions, the deforestation rates are still accelerating due to fuel wood collectors, farmers, ranchers, logging and mining companies.

The loss of forests not only causes an extinction of animal and plant species, and affects indigenous forest dwellers life, but also has severe ecological and economic costs for the country and contributes to global environmental problems.

The biological diversity provides material wealth in the form of food, fiber, medicine, and inputs into industrial processes, e.g. as a valuable genetic pool for potential future biotechnologies. When species become extinct, an irreversible loss occurs. Unlike previous extinctions, the present one is caused principally by human activities: fragmentation and loss of wildlife habitats, overexploitation, environmental pollution and enforcement of man-selected species.

Environmental education programs for all different groups involved in these problems (e.g. rural people, farmers, industrial managers, policy-makers) should give a strong evidence of the short and long-term consequences and negative effects of habitat depletion and wildlife extinction. They should clearly show not only the ecological losses and ethical issues, but also the long-term economical losses and the irreversibility of these processes.

Solid and hazardous wastes

Many cities generate more solid wastes than they can collect or dispose of. Statistics show that the volume of wastes depend on the average income (Table 1).

Table 1: Solid waste generation in the cities (data from Worldwatch, 1987)

<table>
<thead>
<tr>
<th>WASTE</th>
<th>COUNTRY/CITY</th>
<th>ANNUAL AMOUNT (kg per person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFUSE in the cities</td>
<td>USA - New York</td>
<td>564</td>
</tr>
<tr>
<td></td>
<td>Japan - Tokyo</td>
<td>502</td>
</tr>
<tr>
<td></td>
<td>France - Paris</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Hong Kong</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Italy - Rome</td>
<td>251</td>
</tr>
<tr>
<td></td>
<td>Tunisia - Tunis</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>Colombia - Medellin</td>
<td>197</td>
</tr>
<tr>
<td></td>
<td>India - Calcutta</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>Nigeria - Kano</td>
<td>167</td>
</tr>
</tbody>
</table>
Environmenal problems and environmental education needs

Poor neighborhoods generate lower amounts of solid wastes per capita but typically a larger proportion of the waste remains uncollected. Even when the collection of waste is complete, safe disposal often remains a problem. In many developing countries open dumping and uncontrolled land filling are still the main disposal methods. Municipal solid wastes are often mixed with industrial and hazardous wastes and with human excreta. This results in pollution of drinking water with toxic substances and in spread of diseases.

Generation of hazardous wastes is increasing, and varies enormously among countries. Industrialized countries produce on average 5,000 tons for every billion dollars of GNP, while for many developing countries the total amount is only a few hundred tons. For example, Singapore and Hong Kong combined generate more toxic heavy metal industrial wastes than all of Sub-Saharan Africa without South Africa (The world Bank, 1992).

Another problem are toxic chemicals, used in agriculture, industry and households. In a survey carried out by FAO (Food and Agriculture Organization) they found that highly toxic pesticides were widely available in more than 85 developing countries. Furthermore, most of these countries have no adequate system to approve, register and monitor the toxic materials. There is a lack of information about the possible hazards and people are not trained on how to properly use and dispose of toxic chemicals. FAO estimated in 1986 that because of incorrect use and disposal of pesticides, about one million people (most of them farmers in the third world) suffered from the acute poisoning, and an estimated 20,000 people died each year. As an extreme example, in the Philippines the widespread use of toxic pesticides by rice farmers in Nueva Ecija, Central Luzon, increased the mortality by 27 percent (Aspiras, 1990).

Environmental education can contribute by informing on methods for:

(1) proper use of toxic chemicals in agriculture, industry and households, and potential replacement of them by less harmful products;
(2) safer disposal of wastes - e.g. better collection of wastes: sorting of waste for more efficient disposal (recycling of recyclable materials, composting of organic waste); prevention of uncontrolled dumping and disposal; education for more conscious disposal of agrochemicals, hazardous household products and laboratory chemical waste;
(3) source reduction of wastes - e.g. elimination of excessive packaging, designing products to last longer, marketing reusable consumer goods, recycling, and waste minimization in agriculture and industry.

The greenhouse warming effect

Carbon dioxide emissions from fossil fuel burning and other greenhouse gases (water vapor, methane, nitrous oxides, chlorofluorocarbons and ozone), which are primarily a consequence of contemporary lifestyles in industrialized parts of the world, may raise average temperatures on earth. The energy absorbed from the sun must be balanced by outgoing radiation from the earth. Greenhouse gases absorb a part of this energy and re-emit it back to the earth. The size of the effect still remains unclear (global warming from less than 2°C to more than 5°C are predicted for the 21st century). There is even more uncertainty about the consequences - the climate may change drastically, the sea level might rise as the ice caps melt, natural ecosystems may not adapt easily, and the agricultural systems may have to be changed significantly.
Environmental education about the greenhouse effect often focuses on possible global climate changes. In addition, it should point out and explain all the human activities that contribute to the generation of greenhouse gases, and suggest possible alternatives to these practices.

### Energy consumption

Energy consumption is strongly related to income (Figure 2). The average per capita energy consumption is 15.2 times higher in high income economies than in low-income economies, and 3.8 times higher than in middle-income group of countries. However, consumption of commercial energy in developing countries is rising rapidly and will soon dominate energy markets worldwide (Figure 3).

![Figure 2: Energy consumption per capita](image1)

![Figure 3: Average annual growth rate in energy consumption](image2)


Without a change in policy and practice, pollution from fossil fuel generation of electric power will rise tenfold in the next forty years, and more than fivefold from vehicles, industrial emissions and wastes (The World Bank, 1992).

Environmental education might support the introduction of (1) cleaner technologies for energy generation, (2) energy efficient industrial processes and agricultural practices, (3) energy-saving programs in construction of buildings (e.g. better insulation), (4) rationalizations in traffic (public transportation, vehicles consuming less fuel), and (5) household energy saving programs.

---

* GNP per capita: high income economies $7,620 or more; middle-income group of countries $610-7,619; low-income economies $610 or less
Ozone depletion

The increase in ozone depletion is mainly a result of increasing atmospheric concentrations of chlorine resulting from chlorofluorocarbons - synthetic compounds used in many industrial processes and products. A serious consequence of ozone depletion is an increase in the amount of solar ultraviolet radiation reaching the earth's surface. The long-term consequences are harmful for the human health (increase in skin cancer, eye damage, suppressed immune systems in people of all skin complexion) and for the wealth of marine and terrestrial ecosystems. The decrease in the protective ozone layer seems to have occurred more quickly than anticipated and will probably continue for at least a decade, in spite of the restrictions in chlorofluorocarbons production. (The World Bank data, 1992).

Where introduced, environmental education warnings against CFCs products seem to have successful effects on reducing the production and consumption of CFCs. In regions where increased solar UV radiation have occurred, information on how to protect against exposure to the sun rays could be stressed.

Conclusions:

1. Some of the environmental problems are universal, but the most acute environmental problems differ in high- and low-income economies.

2. No general environmental education curricula could be used in all parts of the world. Environmental education programs must refer to local conditions and be designed to address both local and global environmental problems.

3. Environmental education may have strong positive effects on how different environmental problems are dealt with, for instance:
   - reduction of population growth,
   - prevention of waterborne and other infectious diseases,
   - better use of natural resources and materials,
   - introduction of energy efficient technologies in industry and agriculture,
   - energy conservation in building construction, traffic and households,
   - reduced indoor air pollution and reduced emissions of greenhouse, acid rain and ozone depletion gasses,
   - source reduction of wastes (waste minimization in industry and agriculture, elimination of excessive packaging, improvement of durability of goods),
   - improved waste management (better collection and sorting, improved processing, safer disposal of wastes),
   - conservation of natural habitats and wildlife, protection of species,
   - introduction of environmentally sound policies and investments for a sustainable national development.
ENVIRONMENTAL EDUCATION CURRICULA

Goals

Several authors discussing new procedures for developing environmental education curricula stress that it is not sufficient to tell students about ecology, or to present them with an awareness that environmental issues exist. The curriculum must take them beyond these levels and allow them to discover how they interact with the environment themselves. They should assess their own impact on the environment, and must be allowed to develop investigative, evaluative and action skills by using these processes as well as learning about them (UNESCO, Hungerford and Peyton, 1986).

In order to train citizens in problem solving for the remediation of environmental problems and for a better planning, environmental education curricula must provide opportunities for students to experience all dimensions of environmental problem solving. Curriculum developers need to have access to a diversity of case studies which present environmental issues at the individual, local, national and global levels.

Research has shown that the transfer of knowledge and skills is more likely to take place when students (1) have experiences with a diversity of problems, (2) learn how to discriminate between relevant and irrelevant features of situations and to discard irrelevant elements, (3) have the opportunity to use knowledge in a variety of situations.

The transfer and use of acquired knowledge in problem-solving and decision-making situations are not the unique endeavors of environmental education. On the contrary - these are aims of all school disciplines. Several authors report on a diminishing interest at secondary and tertiary level natural sciences, which students find difficult, too academic and not relevant to real life situations. Through the infusion of environmental concepts into science, traditional science teaching approaches may be enriched and will appear more relevant to the majority of students, who do not intend to continue their studies in a scientific field. An example of such an "environmentalized" science program is ChemCom - Chemistry in the Community, a project of the American Chemical Society (ACS, 1993). Several other environmentally-oriented science courses have been launched during the last decade all over the world (Ware, 1992). For instance, there are integrated science courses in Botswana, Jordan, Nigeria, Thailand and USA*; natural science courses in Venezuela and Spain; chemistry and biology in the Netherlands; chemistry courses in Australia, Caribbean, and Philippines; and vocational education programs in Sweden.

* For further details on FACETS integrated science curriculum see Case Study 2.
Which approach: integral or infusion?

Is it better to develop a separate (new) environmental subject or to infuse environmental issues into teaching of the existing school disciplines? This is usually the first dilemma in connection with environmental education. There is some confusion in terminology associated with the two models (interdisciplinary - single subject vs. multidisciplinary - infused model), since the standard use of terms has not yet been fully implemented in the environmental education literature.

Several discussions and analyses of advantages and disadvantages of both educational formats have not lead to a firm conclusion on the best approach, yet in practice the infused model seem to be more frequent.

Table 2: A comparison of single subject and infusion approaches (from UNESCO, Hungerford and Peyton, 1986)

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Single subject approach</th>
<th>Infusion approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of implementation and demand on</td>
<td>can be implement if time permits the introduction of an</td>
<td>more flexible timewise (may be effectively implemented with minimal demands on existing curricular load)</td>
</tr>
<tr>
<td>curriculum load</td>
<td>additional subject to an already crowded curriculum.</td>
<td></td>
</tr>
<tr>
<td>Teacher training</td>
<td>needs fewer teachers but require more in-depth training in</td>
<td>training of more teachers but for a shorter period</td>
</tr>
<tr>
<td></td>
<td>environmental education</td>
<td></td>
</tr>
<tr>
<td>Curriculum development</td>
<td>components easier to identify and sequence</td>
<td>components must be effectively identified, sequenced, and accommodated by the existing curriculum</td>
</tr>
<tr>
<td>Evaluation</td>
<td>easier</td>
<td>comprehensive evaluation difficult</td>
</tr>
<tr>
<td>Age level appropriateness</td>
<td>more appropriate for secondary than primary school level</td>
<td>appropriate at all levels</td>
</tr>
<tr>
<td>Effectiveness in teaching for transfer into real life situations</td>
<td>requires special efforts to effectively teach for transfer</td>
<td>when properly used, teaching for transfer is inherent; infusion permits decision-making to take in other disciplines in an environmental context</td>
</tr>
<tr>
<td>Monetary considerations</td>
<td>a sophisticated course with many field excursions or laboratory equipment may be costly</td>
<td>very dependent on the nature of subjects in the curriculum and on the coordination; may rely on existing equipment</td>
</tr>
</tbody>
</table>
Followers of the single subject (interdisciplinary) approach claim that (1) cutting environmental education into pieces for infusion into other subjects can endanger the integrity of both, scope and sequence of the program; (2) teaching an integral course would require fewer teachers to be trained in the content, skills and methodology associated with the program; and (3) many organizational problems at schools would be avoided. Some authors also feel the environmental education deserve a discipline status, since it is no less an academic discipline than biology, chemistry or social studies.

The followers of an infusion (multidisciplinary) approach have made the following arguments: (1) In most cases, it is difficult to add a new subject on top of the existing ones and change (increase) the agreed amount of teaching hours per year; (2) infusion into different disciplines, such as natural science, health, agriculture, home economics, social studies, languages and arts, does usually not hurt the subject contents, on the contrary, (3) if environmental education is taught as a separate subject, there is a possibility that becomes a traditional style monodiscipline, isolated from the real world. The multidisciplinary approach keeps it more in touch with real life situations; (4) the cross-disciplinary infusion approach provides numerous possibilities of highlighting environmental issues from different perspectives, thus preparing students better for an active participation in problem-solving and decision-making processes.

Environmental education: contents at the secondary level

Traditional environmental education curricula, still in use in many secondary school systems, focus primarily around (1) the basic concepts of ecology, (2) the brief introduction to problems of population growth, shortage of food, resources and energy, and (3) the declaration of environmental problems such as destruction of forests, soil erosion, accumulation of garbage, and pollution of air and water. In technical schools, a simple description of selected environmental technologies is only rarely added.

Traditional environmental curricula are descriptive in nature and aim mostly at providing environmental information. Some of the improved versions have an additional task - to develop environmental awareness. Only a few environmental programs went a step further - train students for environmental problem solving and responsible decision making.

A comprehensive secondary school environmental education curriculum has been designed under the Unesco-UNEP International Environmental Education Program as a prototype curriculum for middle school environmental education (Hungerford, Volk and Ramsey, 1989). The authors have developed a three year integral syllabus, which can also be adapted for infusion into existing school disciplines. The first year is devoted to the ecological foundations. The second year, students learn about environmental problems and possible solutions to them. The entire third year is used for environmental issue investigations and citizenship action training. The main environmental chapters and themes with possibilities for infusion of their environmental contents across the secondary school subjects are given in Table 3.
Table 3: Structure of the UNESCO environmental education curriculum for secondary schools (modified from Hungerford, Volk and Ramsey, 1989):

**CONTENTS**
(amount of time recommended is given in parentheses)

<table>
<thead>
<tr>
<th>INFUSION SUBJECTS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC = natural science, HE = health, SS = social studies, HO = home economics, AG = agriculture, MA = mathematics, LA = languages</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YEAR 1: ECOLOGICAL FOUNDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of ecology</td>
</tr>
<tr>
<td>The role of ecologists (scientific research, environmental impact assessment; urban development, agricultural practices, forestry, commercial fishing, mining, industry, energy production, transportation, sport and recreation)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II. Individuals and populations (7.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual as an organism</td>
</tr>
<tr>
<td>Population as a group of organisms</td>
</tr>
<tr>
<td>Interaction of organisms in communities: macro- and micro-communities</td>
</tr>
<tr>
<td>Ecosystem (biotic and abiotic variables; influences and interactions)</td>
</tr>
<tr>
<td>Biomes (deserts, grasslands, deciduous forests, coniferous forests, tropical rain forests, fresh water, marine, tundra)</td>
</tr>
<tr>
<td>Biosphere</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>III. Ecosystems (20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of ecosystem concept in ecology</td>
</tr>
<tr>
<td>Local and regional ecosystems</td>
</tr>
<tr>
<td>Components of ecosystems:</td>
</tr>
<tr>
<td>Biotic variables (food producers: food consumers: herbivores, carnivores, omnivores, decomposers)</td>
</tr>
<tr>
<td>Abiotic variables (physical factors: sunlight, shade, wind, precipitation, soil moisture, topography)</td>
</tr>
<tr>
<td>Biogeochemical factors (carbon cycle, oxygen cycle, nitrogen cycle, water cycle)</td>
</tr>
<tr>
<td>The critical nature of biogeochemical cycles (circulation of chemicals; waste reduction in natural living systems)</td>
</tr>
<tr>
<td>Ecological niches in ecosystems (generalist and specialized niches; food-related niches)</td>
</tr>
<tr>
<td>Competition in ecosystems (intraspecific and interspecific; competitive exclusion principle and survival of species)</td>
</tr>
<tr>
<td>Tolerance ranges and limiting factors in ecosystems (law of tolerance: optimum, stress and intolerance ranges; the limiting factor principle, examples)</td>
</tr>
<tr>
<td>Summary of the ecosystem concept</td>
</tr>
</tbody>
</table>
### IV. Energy and ecosystems (20%)

<table>
<thead>
<tr>
<th>Topic</th>
<th>SC</th>
<th>HE</th>
<th>SS</th>
<th>HO</th>
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<th>LA</th>
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</thead>
<tbody>
<tr>
<td>Energy as a driving force in ecosystems</td>
<td></td>
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<tr>
<td>The sun as the source of energy</td>
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<tr>
<td>Green plants as the basis for energy production (photosynthesis, food chains)</td>
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<tr>
<td>Energy losses in food chains</td>
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<td>Net primary productivity in ecosystems</td>
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</tbody>
</table>

### V. Ecological succession: Ecosystems change over time (7.5%)

<table>
<thead>
<tr>
<th>Topic</th>
<th>SC</th>
<th>HE</th>
<th>SS</th>
<th>HO</th>
<th>AG</th>
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<th>LA</th>
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</thead>
<tbody>
<tr>
<td>Succession as a natural phenomenon</td>
<td></td>
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<tr>
<td>Characteristics of successions</td>
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<tr>
<td>Primary and secondary succession (sequential development, examples, implications of man activities)</td>
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<tr>
<td>A comparison of early and late succession stages</td>
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</table>

### VI. Populations and their dynamics (20%)

<table>
<thead>
<tr>
<th>Topic</th>
<th>SC</th>
<th>HE</th>
<th>SS</th>
<th>HO</th>
<th>AG</th>
<th>MA</th>
<th>LA</th>
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</thead>
<tbody>
<tr>
<td>Species populations form communities</td>
<td></td>
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<tr>
<td>Characteristics of species populations (interactions, reproductive units, natality, mortality, immigration, emigration, population density, spatial distribution, age structure)</td>
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<td></td>
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<tr>
<td>The importance of population (rather than individuals)</td>
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<tr>
<td>Interactions between populations (commensalism, mutualism, parasitism, predation - characteristics and examples)</td>
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<tr>
<td>Interactions within populations (cooperation, social behavior, competition)</td>
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<tr>
<td>Population stability and instability (biotic potential, environmental resistance, carrying capacity, cyclical populations, eruptive populations, homeostasis - characteristics and examples)</td>
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</tr>
</tbody>
</table>

### VII. Man as an ecological factor (20%)

<table>
<thead>
<tr>
<th>Topic</th>
<th>SC</th>
<th>HE</th>
<th>SS</th>
<th>HO</th>
<th>AG</th>
<th>MA</th>
<th>LA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man: adaptability, environment and economic gain, environmental preservation</td>
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<tr>
<td>Man as an eruptive population (history, present population growth, a question of carrying capacity)</td>
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</tbody>
</table>
### Environmental education curricula

**INFUSION SUBJECTS:**

<table>
<thead>
<tr>
<th>SC</th>
<th>HE</th>
<th>SS</th>
<th>HO</th>
<th>AG</th>
<th>MA</th>
<th>LA</th>
</tr>
</thead>
</table>

Consequences of erupting human population vs. finite resources:
- **Man as builder - urbanization:** man's communities and natural communities, habitat destruction, food and energy in man's communities, urban decay, poverty, crime, urban deterioration and slums, potential solutions.
- **Man as producer of food - agriculture:** agricultural systems, monobiotic agriculture, demands for commercial fertilizers, herbicides and pesticides, consequences of agriculture (soil pollution, ground water contamination, soil erosion, soil salinization, depletion of aquifers, desertification, amplification of toxic chemicals in food chains, retrogression)

**Man and the world's soils:**
- Impact of overgrazing (degradation of grasslands - reasons, problems and possible solutions)
- Impact of row crop production (demand for more agricultural land, destruction of habitats, loss of topsoil by erosion)

**Man and the world's forests:**
- Destruction of forests (gaining agricultural land, logging for fuel, wood as building material)
- Consequences of deforestation (loss of habitats, soil erosion rate, decreasing water absorption capacity of soil, local climatic changes, desertification)
- Problems and possible solutions

**Man and the world's wetlands:**
- Types (swamps, bogs, tidal marshland/estuaries, flood plains/river bottoms, ponds)
- Importance of wetlands (ground water reserves, flood control, fishing, habitats for many species)
- The status of wetlands in the country (USA)
- International consequences of wetland degradation

**Man and the world's wildlife:**
- Importance of wildlife (ecological importance, food and oxygen production, climate moderation, filtration of toxic substances, waste decomposition, recycling of nutrients, control of crop and disease pests, storage of genetic material)
- Status of the world's wildlife (extinction rates)
- Impact of losses on man
- Reasons for wildlife losses (loss of habitat, pollution, killing for food, profit or sport, the pet trade, predator and pest control, introduction of alien species)
- Protecting wildlife (international laws and treaties, wildlife refuges, gene banks, preserving ecosystems)
- Potential for reducing wildlife losses and difficulties in attaining solutions
Critical considerations in regarding man as an ecological variable
Reproductive potential
Cultural limitations (social, religious, political and economic values)
Individual beliefs and values
Man's abilities to change the ecosystems (simplification of ecosystems - monobiotic agriculture; usage of energy and invention of technologies to modify natural and maintain artificial ecosystems)

### YEAR TWO: ENVIRONMENTAL SCIENCE AND ENVIRONMENTAL HEALTH

#### 1. Man: His history and resource consumption (8%)

- Early man: hunters and gatherers (age, survival demands, food, mobility, few material possessions, low levels of stress, low population levels, infant mortality, life expectancy)
- Agricultural societies (domestication of plant and animals, agriculture, urban societies, environmental impact - loss of forests and grasslands, soil erosion, waste disposal problems)
- Industrial societies:
  - Industrial revolution (steam engine and change, internal combustion engine and change, increased energy consumption)
  - Environmental impacts (hazardous wastes, pollution of air and water, environmental degradation, species extinction)
- The relationship of population to resource use, pollution and environmental degradation:
  - Human population growth (in developed and developing countries)
  - Population resource use/abuse (cultural beliefs, renewable resources, nonrenewable resources)
  - Environmental degradation and resource consumption (the commodity concept, implications and risks)
  - Pollution and resource consumption (biodegradable and non-biodegradable pollutants, exposure to pollutants, pollution control in developed and developing countries)
- Interrelationship between population, resource use, technology, cultural beliefs and values

#### II. Soils and allied problems (5%)

- Inorganic and organic components of soil
- Man's dependency on soils
- Soil formation, categories and characteristics of soils (loams, sandy soils, clay soils)
### III. Water and allied problems (10%)

- The world’s water supply
- Renewing water supply (water cycle, use of surface and ground water)
- Problems with water resources:
  - Drought (population variables, poor land use, environmental degradation)
  - Excess water (flooding, effect of deforestation, overgrazing, cultivating marginal land, urbanization)
- Irrigation problems (salinization, water logging soils)
- Management strategies (benefits and problems of dams and reservoirs, water diversion projects, using ground water, desalinization, other strategies)
- Water conservation (water conservation strategies: wasting less water at home, in the industry, reducing irrigation; importance, potentials)

### IV. Food production and hunger (10%)

- The food (plants, animals)
- Food chain losses when meat is produced for human consumption
- Characteristics of major world agricultural systems (labor intensive subsistence farming; land intensive slash and burn agriculture and nomadic herding; land, capital and fossil fuel energy intensive industrialized agriculture)
- World food problems:
  - Population growth vs. food production
  - Nutritional problems (malnutrition, undernutrition, obesity)
  - Food storage/distribution problems
  - Poverty (inability to buy food and to purchase land)
  - Environmental effects of food production (overfishing, overgrazing, soil erosion, salinization/waterlogging, waterborne diseases, deforestation, extinct and endangered species, pollution, loss of genetic diversity, climatic changes, health risks from food additives)
### Environmental education curricula

**INFUSION SUBJECTS:**

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#### INFUSION SUBJECTS:

- **SC** = natural science, **HE** = health, **SS** = social studies, **HO** = home economics,
- **AG** = agriculture, **MA** = mathematics, **LA** = languages.

| The green revolution: (new hybrids, potentials and limitations (increased need for fertilizers and water, soil fertility loss. diminishing return, loss of genetic diversity) |     |     |     |     |     |
| The use/cultivation of unconventional food plants: plants with potential (winged bean, cocoyam, quinoa, others) and cultural biases against new foods |     |     |     |     |     |
| Increasing utilization of fish: world fishery, overfishing, fish farming and aquaculture, increasing fishery production (regulating overfishing, turning to new/unconventional species. constraints to increasing yields) |     |     |     |     |     |
| Sustainable agriculture: self-sufficiency in food production; China as a world leader in sustainable agriculture; potential benefits in the developed nations; reducing enormous waste of food in the developed nations) |     |     |     |     |     |
| Responsibilities of the individual for reducing world hunger. |     |     |     |     |     |

#### V. Forest resources (05%)

- Importance of forest resources (commercial and ecological benefits, climate and pollution control)
- Short term vs. long term benefits of forests: economic vs. ecological values
- The world's forests: locations, loss of forests (clearing land for agriculture and ranching, firewood crises, commercial logging), forest management

#### VI. Plant and animal resources (10%)

- Arguments for preserving plant and animal species:
  - Economic and human needs: food, medicines, soap, scents, oils, waxes, insecticides, fuel, fiber and paper, sport fishing and hunting;
  - Aesthetic/recreational importance
  - Ecological importance (maintaining ecosystems, recycling nutrients, pest and disease control, genetic pool)
  - Ethical importance (the inherent right of an organism to survive; man's inability to understand his relationship with nature)
- Extinction/endangered species:
  - Natural and man caused extinction rates
  - The role of tropical rain forest destruction in extinction
  - Endangered species (loss of habitat, commercial hunting, predator and pest control, pollution, the pet trade, abuse by selected zoos, introduction of alien species)
- Protecting species from extinction (international law and treaties, wildlife refuges, the role of zoos, gene banks, preservation of ecosystems)
- The individual's responsibility for preserving plants and animals
### VII. Air pollution (8%)

**Sources of air pollution**
- Transportation, coal burning power plants and heating, smelters, refineries, pulp and paper mills

**Major pollutants**
- Particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, lead, hydrocarbons, radon

**Impact of air pollution on human health**
- Increased death rate, chronic and acute respiratory diseases, cancer, heart diseases

**Acid precipitation ("acid rain"):**
- Definition, sources of acid rain pollutants, extend of the problem worldwide, effects on lakes, plants, reduction of crop yields, deterioration of buildings and statuary, international dispute, remedies

**Indoor air pollution:**
- Radon gas, products of combustion (carbon monoxide, nitrogen oxides, particulates - smoke)

**Stratospheric ozone depletion from the use of chlorofluorocarbons**

### VIII. Water pollution (10%)

**Sources of freshwater surface pollution:**
- Point sources, non-point sources (soil erosion, sedimentation, construction activities, animal feedlot runoff, pesticide and fertilizer runoff, street/parking runoff, acid mine deposits, acid rain), thermal pollution of rivers and lakes from power plants

**Human disease traced to water pollution**
- Diseases: form bacteria (typhoid fever, cholera, enteritis), viruses (hepatitis, polio), protozoans (amoebic dysentery) and parasites (schistosomiasis)

**Inorganic substances:**
- Arsenic, cadmium, lead, mercury and their effects on human health

**Synthetic organic substances:**
- Benzene, carbon tetrachloride, dioxin, PCB, vinyl chloride, and their effects on human health

**Oceanic pollution:**
- Threats to the ocean's ecosystems, ocean dumping, ocean oil pollution

**Ground water pollution:**
- Ground water as a source of drinking water, sources of ground water contamination, detection and prevention of ground water pollution

**Waste water treatment:**
- Sewage treatment: septic tanks, sewage lagoons, alternative sewage treatment for rural communities, urban sewage treatment (primary, secondary, tertiary), disposal of sewage effluent and sludge, alternatives to large-scale treatment
- The individual's role: safe disposal of household toxic chemicals, recycling waste oil, the use of low-phosphate detergents, limited use of pesticides, bleaches, inorganic fertilizers, using less water
### IX. Noise pollution (05%)

- **Sources and levels of noise in the environment**
- **Effect of noise on the human organism** (hearing loss, stress, effect on unborn children, effect on learning and work performance, sleep disruption, noise and safety)
- **Noise control**: municipal noise control, individual opportunities (sound absorbing materials, wearing ear protection, supporting local ordinances designed to control noise)

### X. Solid waste disposal (10%)

- **Solid waste - definition**
- **Sources of solid waste**: agriculture, mining, industrial, municipal
- **Municipal waste**: paper, food, yard wastes, grass, metals, wood, plastics, rubber/leather, textiles
- **Solid waste produced by different nations**
- **Methods of municipal waste disposal**: water dumping, open dumping - littering, sanitary landfills, incineration, composting, resource recovery (recovery plants, sources separation at homes and businesses)
- **Source reduction of wastes**: marketing reusable consumer goods, elimination of excessive packaging, designing appliances to last longer, beverage container deposits
- **Issues surrounding solid waste management**
- **The individual's obligation/opportunity to help resolve solid waste problems**

### XI. Hazardous waste (7%)

- **Definition of hazardous waste**
- **Sources of hazardous waste**: chemical industries, machinery and transportation equipment industries, motor freight transport, petroleum refining, metals production and fabricating industries, electric, gas and sanitary service industries, household hazardous wastes
- **Hazardous waste disposal in the past**
- **Alternatives of hazardous waste disposal today**: secure chemical landfills; physical, chemical, and biological treatment; deep well injection, incineration, recycling, "midnight dumping"
- **Issues surrounding hazardous waste disposal**
- **The individual's opportunity to help resolve hazardous waste problems** (rational decision-making, enforcement of environmental laws, using less household chemicals, cautiously disposing of household hazardous waste)
**XII. Human population growth and control**

No population can sustain limitless growth

- **Human population dynamics:** birth and death rates, total fertility rates, life expectancy, infant mortality, annual population change rate, doubling time, migration patterns

- **Population age structure**

- **World population size and growth:** arguments in favor and against population growth

- **Economic development and population changes in developed and developing nations**

- **Advantages of family planning combined with economic development:** educational and clinical services, results of family planning in India and China, costs of family planning services

- **Immigration and population dynamics:** legal and illegal immigration, consequences and restrictions

- **Birth control and population dynamics:** preventing pregnancies, terminating pregnancies, future possibilities for birth control

- **Major issues associated with global/national population growth and control**

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**YEAR THREE: ISSUE INVESTIGATION AND CITIZENSHIP ACTION TRAINING**

1. **Environmental problem solving (15%)**

   - **Human-environment interactions**
   - **Quality of life vs. quality of the environment**
   - **Environmental problems and issues:** characteristics of problems and issues, the role of human values and beliefs
   - **Issue analysis:** identification of issues, players, their positions and beliefs; analysis of belief statements for underlying values
   - **Examples (models) of issues**
   - **Applying issue analysis skills to discrete issues**

2. **Identifying issues and preparing research questions**

   - **Identifying environmental issues:** local, regional, national, international
   - **Identifying variables associated with:** human environmental behavior, beliefs and values, socio-cultural implications, ecological implications
   - **Writing research questions for issue investigation:** determining cause and effect relationship; rules for writing research questions; practice in and evaluation of written research questions
### III. Using secondary sources for obtaining issue information (15%)

- Secondary sources of issue-related information: library sources (card catalog, readers guide, cross-indexing), periodicals and newsletters, environmental organizations, government environmental agencies, local resource people, writing letters
- Processing information: obtaining information from all sides of the issue, identifying bias, summarizing
- Reporting: report form and style, citations of references, bibliography

### IV. Using primary sources for obtaining issue information

- Surveys, questionnaires, and opinionnaires: definitions, rules, models
- The interview as an important research technique
- Selecting the appropriate population to be sampled
- Basic procedures to be used in sampling populations
- Data collection strategies
- Developing and using survey instruments/interviews

### V. Interpreting data from environmental issue investigations

- Organizing data in data tables
- Communicating data by graphing: bar graphs, coordinate graphs, pie graphs
- Interpreting data: making conclusions, inferences, recommendations
- Applying data interpretation skills to issue-related data sets

### VI. The independent investigation of a student-selected environmental issue

- Selecting an issue for investigation
- Formulating research questions to guide the investigation
- Collecting secondary information: library search, contacting appropriate agencies/organizations, letters for information
- Collecting primary information: develop appropriate survey instruments, identify appropriate population for sampling, develop appropriate sampling procedures, administer the survey instrument
- Issue analysis/data interpretation: organize the collected data into tables, graphs, text; analyze information for players, beliefs and values; interpret the findings (data-based conclusions, inferences, recommendations)
- Communication of investigation and results: produce a written report; present issue investigation to classmates
### VII. Issue resolution: skills and applications

<table>
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<tr>
<th>Citizenship responses to issues and their effects</th>
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<tr>
<td>Principles of environmental citizenship action - the responsibilities to be knowledgeable about the issues, to be skilled in issue resolution, knowing the effect of action, considering potential negative and positive effects</td>
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<td>The methods (modes of citizenship action): persuasion, consumerism, political action, legal action, ecomanagement (physical action)</td>
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<td>Effectiveness of individual vs. group action</td>
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<td>Guidelines for decision-making: sufficient evidence, alternative actions, relative effectiveness of actions, legal, social and economic consequences, personal values and beliefs, ability and courage to take the action, time needed to completion, ecological consequences</td>
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<td>Applying issue resolution skills: producing, evaluating and carrying out the plan of action: evaluating the effectiveness</td>
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As seen from the infusion possibilities, the introductory environmental knowledge is almost exclusively part of the natural sciences. Later, social sciences are gaining importance, and basic concepts may be applied in agriculture, health education and home economics. The third year (action training) is strongly cross-disciplinary and complex. However, action skills are primarily focused on environmental citizenship actions, adopting methods from social sciences.

Unfortunately, the program seems to be weak on practical (experimental) laboratory and field works linked to natural sciences and technologies. Practical experience related to natural phenomena and technological processes is necessary for a competent decision making and problem solving ability, especially within (1) issues related to transfer, adoption or elimination of "dirty" and "clean" technologies; (2) energy generation, use and conservation; (3) use of natural resources and materials; and (4) understanding of ecosystems for more efficient protection of habitats and wildlife. Because of this weakness many opportunities for strengthening practical science education in a cost-effective and highly motivating fashion may be missed.
Examples of themes for infusing environmental content into secondary school subjects

In the following chapter are listed the environmental topics that are suited for infusion into biology, chemistry, agriculture, health education, home economics, physics, mathematics, geography, history/social sciences, economics, technology and engineering, safety at work, religion/ethical education, languages and arts (Sources: Anderson, 1981; Bauer, 1987, Boh, 1991; Boh and Kornhauser, 1992; De Camargo, 1987; Camougis, 1981; Colon, 1993; Czelik-Eisenberg, 1991; FAO, 1988; Grabe, 1987; Hassan and Hutchinson, 1992; Hungherford, Volk and Ramsey, 1989, Kapor-Vijay and White, 1992; Osujih, 1992; Sauthwick, 1985; VanDeVeer and Pierce, 1986; Unesco-UNEP, 1985):

Biology

- Ecological foundations (all topics of basic ecology)
- Specialized ecosystems and their characteristics
- Characteristics of natural habitats, their destruction and possibilities for protection
- Optimal living conditions for individuals, population groups and ecosystems
- Effect of specific pollutants to plant, animal and human organism
- World's wildlife, extinction of species, and their protection
- The need for animal testing and the possibilities to substitute it by other test systems
- Genetic engineering, biotechnology and the environment
- Alternative food and fuel plants
- Medicinal plants and their applications
- Natural materials - their characteristics, production, uses and degradation
- Biological decomposition of biodegradable materials and wastes
- Biological and biochemical processes of waste treatment technologies
- Biological analysis and tests in pollution monitoring
Chemistry

- Biogeochemical cycles in ecosystems
- Photosynthesis and food chains
- Major pollutants of air, their sources and chemical reactions
- Chemistry of acid rain
- Chemistry of ozone depletion
- Greenhouse gasses
- Major water pollutants, their sources and chemical reactions
- Chemical industry and the environment
- Man-made chemicals and materials in the natural and urban environments
- Hazardous chemicals at home, at school, in chemical industry and agriculture
- Chemical analysis in pollution monitoring
- Chemical processes in waste water treatment procedures
- Chemical processes in solid and hazardous waste treatment

Agriculture

- Soil, its components and characteristics
- Foundations of plant ecology
- Photosynthesis as the main generator of energy in ecosystems
- Effect of land cultivation practices on soil degradation
- Deforestation, soil erosion and desertification
- Environmental effects of cattle breeding and fishing
- The green revolution and agricultural biotechnology
- Effects of fertilizers and agricultural toxic chemicals (insecticides, herbicides, fungicides, rodenticides, molluscicides) on soil, water, plants, animals and humans
- Waste minimization and energy saving programs in agriculture
- Residues of agrochemicals in food products
- Possible soil conservation strategies
- Improving land use (identifying causes of land misuse, implementing the improvements)
- Environmentally-sound agricultural practices and technologies
- Bio-farming, health food, "green" products
- Unconventional food and fuel plants
Health education

- Environmental health and sanitation
- Human reproduction, family planning and the environment
- Food production, nutrition and the environment
- Food contamination and preservation
- Effects of air and water pollution on human health
- Water borne diseases and their prevention
- Effect of indoor air pollution on human health
- Hazardous chemicals, hazardous wastes and human health
- Noise pollution and human health
- Sewage treatment methods and technologies
- Treatment of wastes from hospitals
- Medicinal plants and alternative medicine
- Environment, stress and health
- Hazards of alcoholism, smoking and drug abuse

Home economics

- Human reproduction and family living
- Home sanitation and diseases
- Drinking water purification
- Water conservation strategies at home
- Food waste in households
- Garbage disposal
- Waste minimization and recycling of materials at home
- Energy consumption and possibilities for energy saving at home
- Decreasing indoor pollution (smoke, noise)
- Toxic chemicals and hazardous waste related to household products
- Environmentally-sound consumer behavior
### Environmental education curricula

#### Physics
- Physical factors in ecosystems
- Energy definition and forms
- Energy sources and resources
- Energy chains and the transport of energy
- Efficiency of energy transformations and optimal uses
- Energy and entropy
- Energy production for human activities (power plants), energy losses,
- Energy consumption and strategies for energy conservation
- Alternative sources for energy production
- Physical processes and technologies in waste water, solid waste and hazardous waste treatment
- Nuclear power plants and radioactive wastes

#### Mathematics
- Calculations, e.g. on population dynamics, food chain energy losses, etc.,
- Mathematical and statistical methods in environmental research
- Organizing environmental data (tables, graphs, databases)

#### Geography
- Climatic changes as a consequence of environmental mismanagement
- Deforestation, soil erosion, drought and flooding
- Human population and its dynamics
- Effects of rural and urban populations on the environment
- Effects of human activities on the environment
- Industrial regions and the environment
- Tourism and the environment
- Preparation of environmental maps
- Establishment of local plans for spatial and resource management
- Geographical information systems in environmental management, planning and research
**Environmental education curricula**

**History/Social science**

- Analysis of attitudes toward the environment
- Historical development of environmental pollution and protection
- Human population, its dynamics and interactions
- Human needs vs. finite resources
- Poverty and economic development vs. environmental protection
- Environmental problems in rich economies
- Effect of cultural (social, religious, political, economic) values on environmental issues
- War, peace, security and the environment
- Effect of individual beliefs and values on environmental issues
- Effect of education on individual's environmental behavior
- Environmental legislation
- Opportunities for an individual to help resolve environmental problems

**Economics**

- State of the environment in rich and poor economies - effect of country's income on the characteristics of environmental problems
- Economic prosperity as a basis for environmental protection
- Economic price of polluting
- The social cost of pollution
- Tradeoff between employment and harming the environment
- Short-term and long-term economical consequences of intensive environmental exploitation in agriculture, forestry, industry, tourism
- Economic decision making between producers, consumers and environmentalists
- Regulatory measures that give incentives for protecting the environment
- Promotion of environmental protection by financial subsidies or sanctions
- Environmental legislation and sanctions for polluters
- Costs and economic advantages of environmentally friendly technologies and products
- Effects of energy prices on energy consumption and environmental protection
- Promotion and marketing of "green products"
Environmental education curricula

Technology and Engineering

- Effects of the industrial revolution on the environment
- Generation of energy and environmental impacts
- Alternative technologies for energy generation
- Technological processes and the consumption of energy
- Energy consumption minimization in industrial processes
- Dirty and clean technologies
- Waste minimization in industrial processes
- Closed cycle technologies
- Types and characteristics of industrial wastes (vapors and gases, industrial waste water, solid wastes, hazardous wastes)
- Technological processes for treatment of municipal, agricultural and industrial wastes
- Technologies for drinking water purification
- Prevention of vibration and noise pollution
- Pollution cycles of technological products: during manufacturing, while using the product, after the useful period is completed (turns to waste)
- Environmentally friendly industrial raw materials, products and packaging
- Rational management of natural resources, substances and energy
- Effects of technology and engineering activities on natural ecosystems
- Fundamentals of environmental impact assessment
- Management of industrial wastes
- Information technologies for environmental management and research
- Environmental monitoring technologies
- Environmental legislation and regulations in technology and engineering

Work safety (technical and vocational schools)

- Fundamentals of environmental toxicology
- Safe storage, transportation and use of volatile, inflammable, corrosive, reactive and toxic substances,
- Proper handling with (and use of) agricultural and industrial chemicals,
- Proper disposal of liquid and solid wastes,
- Proper management of hazardous wastes,
- Pollution of working environment (noise, vibrations, air pollution),
- Technologies and materials for improving working environments (reduced pollution, improved safety),
- Toxic chemical and waste emission risks,
- Strategies and procedures in ecological calamities
### Environmental education curricula

#### Religion/Ethical education/Philosophy

- Value systems and the environmental issues
- Humanistic considerations: stabilizing population, poverty alleviation, economics and health
- Cultural and religious constraints in implementation of environmental measures
- Environmental ethics: human rights, animal rights, the value of lives, preservation of species, respect for natural and cultural diversity
- Nature and environment in different religions and philosophies
- Global pollution, its causes and effects in rich and poor countries

#### Languages

- Improving speaking abilities: environmental discussions, role playing, simulations, interviews
- Improving writing abilities: preparing questionnaires, opinionnaires, written reports, letters, summaries, bibliographies, etc. on environmental issues
- Improving skills in foreign languages: reading and translation of environmental texts, speaking about the environment (e.g. simulated conference speech)
- Collecting literature, using different library and database sources for obtaining environmental information
- Environmental language and environmental dictionaries

#### Arts

- Environmental topics in photography, drawing, painting, sculpturing, music, etc.
- Graphical design of environmental publications
- Design of environmentally friendly packaging
A science teacher can introduce environmental education in connection with almost any concept of the subject by presenting the concept from at least one of the following three viewpoints:

1. How can the concept improve the understanding of environmental phenomena?
2. What is the role of the concept in the environment?
3. How could it be used to solve environmental problems?

What is the essential knowledge that should be acquired in secondary school environmental education?

What is the most basic knowledge that a secondary/high school student need to acquire to be environmentally literate? The answers are probably as many as the environmental educators working in the field.

The following example of a secondary/high school basic curriculum core in environmental education combines the three aspects, that may be essential for proper understanding of environmental issues. These are:

1. Simple or simplified fundamental scientific concepts necessary to understand the main natural processes,

2. Applied scientific knowledge for better understanding of the living environments, activities, materials and technologies, and

3. Specific environmental knowledge about environmental problems and possibilities for their solution.
1. IMPORTANT FUNDAMENTAL SCIENTIFIC KNOWLEDGE

Fundamentals of biological taxonomy, chemical nomenclature and SI metric system

Levels of complexity in natural systems
biosphere - biomes - ecosystems - communities - populations - organisms - organs - tissues - cells - subcellular components - molecules - atoms - subatomic structures

Basic ecology
The ecosystem concept: biotic and abiotic factors
Characteristics of individual organisms
Population dynamics
Interspecific and intraspecific interactions
Tolerance ranges and limiting factors
Adaptation, natural selection, and evolution
Major biomes
Main characteristics of terrestrial, freshwater and marine environments

Natural cycles
Water cycle
Biogeochemical cycles
Energy cycle
Food chains

Basic understanding of biochemical processes
Photosynthesis
Respiration
Biosynthesis
Biodegradation
Inheritance, nucleic acids and genetic code

Energy
Basic laws of energy
The entropy concept
Energy transformations and losses
Production and consumption of energy
2. APPLIED SCIENTIFIC KNOWLEDGE

Materials in daily life
- Origin (from renewable or non-renewable resources).
- Characteristics during their use (e.g. inert, hazardous, durable).
- Main usage (e.g. construction materials, technological products, packaging, clothing, food, pharmaceuticals, agrochemical, household chemicals)
- Disposal (e.g. reusing, recycling, composting, burning/incinerating, landfill disposal)

Energy in daily life
- Energy in living organisms (incl. food composition and digestion)
- Energy for human activities: power plants, alternative sources of energy
- Energy in industrial and agricultural processes, traffic and transportation, heating and cooling systems, etc.

Processes and technologies in daily life:
- Main types (world and local perspective)
- Benefits for human life and negative environmental effects
- Examples of environmentally-sound processes and technologies

Main pollutants, sources and possible solutions (basic scientific knowledge)
- Air pollution
- Water pollution
- Pollution of soil
- Radioactivity
- Noise, vibrations
- Pollution of urban environment, working place and home
- Alcoholism, drugs, stress

Fundamentals of waste management and treatment, pollution prevention and energy conservation

Environmentally sound development:
- how to choose the right materials, technologies, industries, agricultural practices, management of resources, consumer's behavior.
3. ENVIRONMENTAL ISSUES: PROBLEMS AND SOLUTIONS

Global concerns:
- Human population growth
- Environment deterioration and human health
- Food production and consumption (quantity and quality)
- Resources consumption and protection: water, fuel, minerals
- Destruction and protection of forests
- Soil degradation, erosion, siltation, desertification, irrigation, salinization
- Global air pollution (greenhouse effect, ozone depletion, acid rain)
- Global marine pollution
- Wildlife, biodiversity and protection of species

Human activities and environment
- Impacts of agriculture, forestry, industry, mining, fishing, urbanization, traffic, war

Local environmental problems and possible solutions
- Identification of country-specific and local problems
- Searching for solutions (e.g. improving agricultural practices, local waste management, changing consumer's habits, water and energy saving and waste minimization at home and at school).

Environment and social sciences
- Family planning issues
- Effects of religion, culture and education on environmental problem solving
- Individual beliefs and values in environmental issues
- Environmental ethics
- Environmental regulations and legislation
- Short-term versus long-term benefits in environmental planning and management
- Individual responsibilities for preserving environment (What can be my contribution)

Basics of environmental research and project work
- Methodology of designing, testing, evaluating and optimizing research and project work
- Information gathering, analysis, structuring, and interpretation
- Scientific observation, environmental sampling, measurements, tests, experiments
- Setting up, testing and optimizing research hypothesis
- Results interpretation, presentation, and dissemination
Conclusions

1. An environmental education curriculum should not only present the basic ecological concepts and promote an awareness of environmental problems, but should improve the understanding of environmental issues and encourage a search for solutions and active participation in problem solving.

2. Both, the single subject and the infusion approach are appropriate for the introduction of environmental education at the secondary level. The choice depend on the existing educational policy, curriculum time frame, existing school subjects, and teachers' qualifications.

3. In the infusion approach, the environmental concepts may be introduced through a variety of school disciplines, such as biology, chemistry, agriculture, health education, home economics, physics, mathematics, geography, history/social sciences, economics, technology and engineering, safety at work, religion/ethical education, languages and arts.

4. A secondary/high school environmental education has to provide the (a) fundamental scientific knowledge necessary to understand the natural processes, (b) applied scientific knowledge for better understanding of every day life situations and environmental issues, and (c) specific environmental knowledge about environmental problems and possibilities for their solution.

5. Students need to acquire a strong theoretical background as well as practical experiences (laboratory and field work) with a diversity of environmental concepts and issues.

6. Environmental education curricula should constantly be updated with new discoveries, experiences and methodological approaches. Therefore, continuous cooperation between teachers and educators with scientists, researchers, engineers and other specialists is essential.

7. Through the infusion of environmental concepts into science, traditional science teaching approaches can be enriched and become more relevant to the majority of students, who do not intend to continue their studies in a scientific direction.
METHODOLOGICAL APPROACHES TO ENVIRONMENTAL TEACHING

Environmental education goals

Environmental educators have spent considerable time and effort defining goals and purposes of environmental education. The general consensus is that environmental education should have the purpose of

"training world inhabitants who are both capable and willing to choose lifestyles and behavior which allow the environment to maintain itself as a productive and supportive ecosystem, i.e. to train learners to become environmentally literate citizens who can participate in problem-solving and decision-making processes and thus contribute to the improvement of environmental problems" (Unesco, 1989).

This task demands a number of prerequisite skills. A discussion guide for Unesco training seminars on environmental education (Hungerford, Volk and Ramsey, 1989) suggests the following necessary abilities that the student should acquire through environmental education:

1. identify environmental issues,
2. analyze issues correctly and identify individuals or groups involved, their beliefs and values,
3. investigate issues from different viewpoints (scientific, social, economic, political, legal),
4. be able to evaluate the proposed solutions and determine the most effective ones,
5. participate in the execution of the action plan.

However, meeting these instructional objectives is not an easy task for teachers and other environmental instructors. For such environmental instruction, teaching has to be organized in a different way than traditional classroom lectures and should include a variety of teaching methods, techniques and resources (Table 4).
Table 4: Suggestions of teaching methods and resources for the main four instructional levels (adapted from Unesco - Hungerford, Volk and Ramsey (1989) and Maczynikowski, 1988):

<table>
<thead>
<tr>
<th>GOAL LEVEL</th>
<th>TARGETED KNOWLEDGE AND SKILLS</th>
<th>TEACHING METHODS</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) ecological foundation level</td>
<td>scientific knowledge needed to understand and investigate environmental issues</td>
<td>lectures and discussion</td>
<td>lecture notes, overheads, worksheets, follow-up panel discussions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reading and discussion</td>
<td>printed materials (textbooks, journals, research reports)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>viewing and discussion</td>
<td>video tapes, movies, filmstrips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>models and simulations</td>
<td>three-dimensional models, printed models and simulations, computer graphics and simulations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>laboratory experiments and field studies</td>
<td>school laboratories, environmental science youth clubs, environmental centers, natural parks, natural and urban environments (task-oriented field trips)</td>
</tr>
<tr>
<td>(2) conceptual awareness level</td>
<td>conceptual knowledge (understanding the complex structure of a problem) - analyzing the ecological and social/cultural implications</td>
<td>lectures and discussions</td>
<td>lecture notes, overheads, worksheets, follow-up panel discussions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reading and discussions</td>
<td>printed materials (journals, newspapers, reports, research studies, monographs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>viewing and discussions</td>
<td>video tapes, specialized movies, TV series and round-table discussions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>case studies</td>
<td>teacher developed or printed case studies, community resource people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>brain storming</td>
<td>teacher organized brain storming sessions (focus on student involvement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>issue analysis (positions, beliefs, values)</td>
<td>worksheets involving the issue analysis procedures, films and print materials as referents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field trips</td>
<td>local environmentally impacted sites</td>
</tr>
</tbody>
</table>
**Cross-disciplinary, problem solving approaches**

Although the need for an integrated approach to environmental education is becoming widely recognized, most educational institutions still tend to emphasize a traditional disciplinary approach that may lead to narrow specialization. A number of monodisciplinary and often isolated environmental topics have been introduced into most school curricula. However, it is rare to find...
comprehensive approaches that integrate all the different aspects of environmental problems, search for their solutions and prepare students to take responsible environmental decisions.

The cross-disciplinary, problem-solving approach encounters a number of traditional constraints to the successful environmental education program development. Jacobson and Robinson (1990), have found that multidisciplinary programs (where a theme is infused into various disciplines) and interdisciplinary programs (where a number of disciplines are synthesized into a common program) face several major obstacles, that are present at all educational levels:

a) Structure
Cross-disciplinary environmental efforts require the cooperation of several teachers, researchers, programs or departments. Thus, the mutual interests of teaching, research and administration from diverse disciplines must converge to make the program viable. Experience has shown that it is more efficient to develop or introduce new environmental programs in already established cross-disciplinary institutions than in traditional institutions.

b) Communication
Communication between different specialists working together in a cross-disciplinary education program seems to be difficult. Prior experience among project members, especially the coordinators, in cross-disciplinary work greatly reduces the communication and adjustment problems. In the case of larger projects, an automated communication system, e.g. an interactive computer network linked to information systems, can substantially improve the exchange of information and increase the effectiveness of a project.

c) Curriculum
The lack of cross-disciplinary training is in general recognized as one of the most important issues facing the scientific community today. In spite of this, the basic conflict of monodisciplinary depth versus cross-disciplinary breadth remains unresolved. A multidisciplinary integration or an interdisciplinary synthesis may be the optimal model for environmental curricula.

d) Evaluation
Multidisciplinary programs are more difficult to evaluate than professional or single-discipline programs.

e) Research
Cross-disciplinary teaching at higher levels of education should be accompanied by cross-disciplinary research opportunities. Discipline-oriented research is still regarded the "normal way" for science advance, while cross-disciplinary research is considered "something of an art rather than a science" (Jacobson and Robinson, 1990). In professional cross-disciplinary environmental research, curriculum development, or teaching, there is a need for a close collaboration between specialists in different subjects, each with a deep knowledge of their disciplines, using different problem-solving approaches, performing different roles in solving the common problem, and feeling both individual and group responsibility for the final product.

f) Reward
It is difficult to build a reward structure (funds, recognition, promotion) into a multidisciplinary program, and even harder to do so in an interdisciplinary one.
Methodological approaches to environmental teaching

The problem-solving approach requires that the teacher not only has a deep understanding of environmental phenomena and processes, but also the necessary skills to organize, conduct, supervise and evaluate problem-solving activities of the students. Pomerans, House and Heath, (1985) describe and analyze different pedagogic procedures that can be used in environmental problem solving. These are:

(1) group discussions,
(2) guided environmental interpretation,
(3) clarification of values,
(4) games and simulations,
(5) experimental demonstration workshops,
(6) practical action projects, and
(7) action-oriented research.

However, there is no universal approach or method that can be adopted in all countries, for all students and for all environmental education situations. Each teacher will have to choose the most appropriate teaching style, methods and techniques for the given situation.

Examples of non-traditional teaching methods and techniques in environmental education

Research on efficiency of information transfer shows that the average student remembers less than 10 per cent of what he reads, about 20 percent of what he hears, and about 30 percent of what he sees. The combination of sight and sound together increases retention to more than 50 percent, and subsequent discussion can further improve the retention to above 70 percent (Boulton, 1987). This illustrates the significance of using different teaching methods and techniques in all school disciplines, including environmental education.

A summary of selected teaching methods and techniques, appropriate for environmental teaching, is given below. The list is not intended to be complete, but it illustrates different opportunities in environmental teaching. Their applications in environmental programs, teaching units and laboratory experiments are listed in the Case Studies.
### Inquiry methods

Table 5: Examples of inquiry methods in environmental teaching (modified from Unesco-UNEP, 1986)

<table>
<thead>
<tr>
<th>METHOD</th>
<th>PROCEDURE</th>
<th>AIMS</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry</td>
<td>Searching for an answer through a series of intellectual activities (gathering data, analyzing, discussing, hypothesizing, experimental testing, generalizing) to make an experience or a scientific problem understandable.</td>
<td>Developing student's curiosity; encouraging students to investigate and discover for themselves; training them to be able to deal with complex topics.</td>
<td>Heavy metals in food: gathering data about contaminated food, analyzing the reasons and sources, setting hypotheses, laboratory testing and field testing (e.g. vegetables growing by the heavy traffic roads), drawing conclusions.</td>
</tr>
<tr>
<td>Discovery through inquiry</td>
<td>Students gather data about the problem by asking critical thinking; developing inquiry questions (and not by performing experiments), develop a concept, discuss it and draw conclusions. The technique can utilize different tools: stories, photographs, slides, films.</td>
<td>Developing abilities to ask precise and target-oriented questions.</td>
<td>A map and two photographs are shown to the students: a polluted river at present and the same river thirty years ago, when it was still clear. By asking questions, students have to identify the river, the causes of pollution and their effects to the environment. Follow up: field trip to a nearby river, planning activities to improve the condition of the river.</td>
</tr>
<tr>
<td>Invitation to inquiry</td>
<td>Emphasis on how data are acquired and turned into knowledge, e.g. (1) presenting a problem, performing experiments, analyzing data, interpreting data; (2) interpreting a given set of data to form a conclusion; (3) developing hypotheses (possible explanations) about the problem situation, and testing them.</td>
<td>Developing creativity and imagination (science is not just learning what is already known); developing abilities to analyze data, predict and plan the testing procedure.</td>
<td>Presenting the problem of floods in Asian countries, their ecological, social and economic consequences. Providing data on the climate, rainfalls, geographic and geological characteristics, and on human activities in the region. Students have to identify possible causes, analyze them and set hypotheses.</td>
</tr>
</tbody>
</table>
Communication methods

Discussions

Panel discussions and debates on environmental issues can be used effectively to present conflicting viewpoints and evaluate different beliefs and values. They can directly involve all the participants in a class including groups of students with different views. For an effective panel discussion education specialists recommend four phases: (1) presentation of positions - panelists on each team introduce their positions, (2) clarification of positions - question and answer session between the teams, (3) free-form discussion - points, counterpoints, rebuttals, general discussion, and (4) audience participation - questions and comments from the audience (Unesco - Hungerford, Volk and Ramsey, 1989).

These discussions and debates are especially appropriate for secondary school students; because they train them in proper communication skills for real-life situations.

Role playing and simulations

Several authors recommend the practice of role playing and simulations of environmental meetings, commissions, public hearings, etc., as a way to provide students with adequate practice for making important decisions and for developing action-oriented human relation skills. This also provides an accurate demonstration of the relevance of textbook information to life experiences. Role playing can be performed in small or large groups, but the students should study the environmental issue in advance. During a simulation, neither students or the instructor are allowed to step out of their roles.

Audiovisual techniques

Filmstrips and slide programs

If technical facilities are available in the schools, filmstrips and slides offer several advantages: (1) they are relatively inexpensive to acquire and produce; (2) they are flexible and can be rearranged to suit the presentation, mixed with other resource materials as required, and are readily updated by substitution or addition of new material; (3) original slides and good copies may produce large pictures if a good projector is available.

Although a number of "magic boxes" are advertised, which can link the slide projector to a tape recorder, the live presentation of a teacher or environmental specialist is usually more effective (Boulton, 1987). The exception might be special programs, where the sound is very important, e.g. the reproduction of characteristic sounds of animals.

For Third World use, Boulton (1987) recommends slide projectors. For instance, two slide projectors with long-focus lenses, and a portable AV/amplifier/cross-fade system, cost the same as a 16 mm projector, but the possibilities for more creative user are virtually limitless. More sophisticated units can control several projectors and dissolving from one image to the next. Such expensive techniques might be justified for permanent installation in environmental visitors centers and for other special presentations.

A universal requirement is a source of electricity and a quality projector. Some projectors can be adapted to operate from 12-volt car batteries, though they draw heavily on the current and the batteries must be recharged very frequently. They also operate on petrol generators. The World
Wildlife Found is using such equipments for rural conservation programs in developing countries (Boulton, 1987).

**IVD Interactive Video Disc technology** is one of the new challenging tools in distance education systems. The standard equipment requirements are: a simple personal computer (e.g. 286 PC) equipped with video overlay board, an interactive program, and a visual database on a laser disc. In combination with a 30 minutes videotape, the system can provide as much as 25 hours of an interactive training instruction at a cost breakdown between $35 to $75 per trainee week (Edison, 1993). The IVD can simulate the field experience on-screen that can complement (or substitute) field or laboratory work education. The system has been successfully implemented in water management training programs for engineers in India. Similar possibilities are been discussed for use in distance education of newly privatized farmers in Russia. In environmental education, IVD learning packages might be useful in environmental learning centers, in introductory courses for secondary students project work, and especially for the distance environmental training of in-service teachers.

**Information sources**

The quality of contemporary education, research and development depends to a large extent on the efficiency of the international transfer of scientific information. The use of information methods and techniques is of particular significance for development of research hypotheses, as well as in teaching and learning (Kornhauser and Boh, 1992).

Using a single textbook or only lecture notes is not sufficient. In teaching based on problem-solving and decision-making situations, students have to collect as complete information as possible in order to acquire the scientific knowledge needed; in particular, they must gather enough statistical data on a selected environmental issue and get acquainted with different views and positions of the parties involved. Different sources of data are available for primary and secondary school students:

**Direct information acquisition**

a) asking target-oriented questions to environmental specialists, managers, the local population, exchange of information between teachers and classes working on different aspects of environmental topics;

b) formulating letters with precise questions regarding environmental organizations, industries and governmental institutions;

c) introducing questionnaires and opinion surveys for a broad spectrum of the population affected.

**Literature sources**

a) Primary sources of literature are numerous and include newspapers, scientific journals, textbooks, monographs, encyclopedias, technical manuals, statistical yearbooks, environmental research reports, marketing and advertising materials, pamphlets; for more serious learning and project work also Ph.D. thesis, elaborate studies, market analyses, know-how offers and patents.

b) Secondary literature sources provide bibliographic data and often include an abstract with condensed information on the contents of publication. Indexes and abstract books are available in many environmental information centers and larger libraries.
Computerized databases

Bibliographic computerized databases are rapidly replacing large-volume books of abstracts and indexes. In addition to bibliographic databases, factual databases, which offer the user sorted and well structured information on specialized fields, are becoming more widely available. Most of the large international databases are available on-line, several of them also on CD ROM. Small specialized databases, created for educational and research purposes, run on personal computers. They may be designed and built by secondary school students, e.g. for organizing the environmental library, building a registry of local natural resources and wildlife or a registry of local polluters and wastes, and for collecting and processing data from environmental monitoring and youth research projects.

Practical laboratory instruction

Many educators are aware of the importance of practical laboratory work. Most agree that "hands-on and minds-on" environmental science promotes intellectual development, enhances the learning of environmental concepts, develops problem-solving skills and creative thinking, and increases the understanding of environmental processes, general scientific concepts and technological problems. Yet, in reality, practical forms of environmental teaching are often neglected.

The main constraints in increasing the laboratory activities seem to be: (1) insufficiently trained teachers, (2) lack of effective teaching units based on experimental work, (3) lack of science laboratories, (4) insufficient (or non-existent) laboratory equipment, (5) problems with equipment maintenance and resupply of consumables, (6) insufficient safety procedures, (7) lack of time in an overcrowded curriculum.

Teacher training is in most countries the most critical problem in introducing hands-on environmental science. If the teachers are well trained and motivated, most of the problems caused by modest physical conditions may be overcome. In both low- and high-income countries, modern practical programs have been successfully implemented in much simpler surroundings than those generally recommended.

Numerous creative and cost-effective methods and techniques in hands-on environmental education exist, for example:

(1) Environmental experiments related to chemistry can be performed on micro-scale (less chemicals are needed, experiments are safer), or with natural or locally available substances and materials (e.g. from a grocery store, or even no-cost waste products).

(2) Recycling of used laboratory chemicals results in financial benefits, reduced pollution and directly illustrates environmentally sound behavior.

(3) Low-cost, locally made equipment (either by teachers or by students themselves), can be used instead of commercial laboratory equipment. The main benefits are (Musar, 1993): lower cost, easier maintenance and repair, better availability of spare parts, higher relevance to the curriculum, higher self-reliance, and flexibility in adaptation.
Methodological approaches to environmental teaching

(4) In many cases spirit burners may be used instead of gas, and, due to the lower temperature, expensive laboratory glassware can be replaced by or constructed from low-cost or no-cost household products (bottles, jars, cans, strainers, etc.).

(5) The local environment around the school may provide a rich source of environmental hands-on experiences. It is at least as readily available as a school laboratory. Even in schools with well equipped science laboratories, a part of environmental practical work may be performed outside school (see the case studies, an example from Sweden, Egneus and Tullberg, 1985). In situations where laboratories are not available or are inadequate, the local environment may be an excellent substitute for laboratory experiments in environmental education.

(6) A school garden can offer numerous environmental hands-on activities related to agriculture, biology, physics, and home economics.

(7) When a school garden is not available, several environmental concepts can be illustrated in a regular classroom by growing plants in pots, maintaining simple ecosystems (vivarium with insects, aquarium, terrarium), or by constructing simplified biological reactors for organic waste treatment.

(8) Several environmental kits are available, which contain written instructions and all the necessary equipment and reagents for practical work. The Royal Society for Nature Conservation, UK, for instance, has developed "The River Watch Pack" and "The Ozone Project Pack" and distributed them to schools and environmental centers in and outside the country.

(8) For special environmental research projects, science-oriented secondary students may use existing facilities in laboratories of local industries and research institutions. In some countries, this is already a well established practice.

Field trips and excursions

Environmental learning activities outside the classroom enrich the teaching process by introducing first-hand experiences of environmental phenomena, materials, living organisms, processes and technologies. A field trip or excursion is most effective if it is task oriented and carefully planned. Students have to get the prerequisite knowledge before the trip and know their responsibilities and duties in advance. An active participation role has to be assigned to each student. The field activities (e.g. collection of data, taking samples, studying the ecological phenomena, learning about the waste treatment technologies, etc.) must be followed by later analysis of data, presentation of results and discussions.

Field trips by groups of students may sometimes present a potential hazard to sensitive natural environments. Therefore, field activities must be designed in a way that affects the area visited as little as possible, and possible risks must be discussed in advance.

Project work

The interdisciplinary environmental teaching is often combined with project work. The proceedings of a Nordic Workshop on Teaching Science and Technology in an Interdisciplinary
Methodological approaches to environmental teaching

Context recommend the following basic guidelines for science and technology project-oriented teaching (Thulstrup, 1985; Egneus and Tullberg, 1985):

- students need to have a fixed goal and well defined working plan for the project; their participation during the planning is essential;
- a continuous communication between teachers and students is important during all stages of project work;
- an active participation of all students have to be planned and assured during project activities;
- the teacher should function as a resource person and should not limit the possibility of imaginative work by the students;
- other resource persons can be involved (e.g. environmental specialists, researchers, engineers, managers, farmers, local people, etc.) and the cooperation can be established with the society outside the school;
- the project has a goal in itself, and the evaluation should be performed on the basis of the project idea;
- project reports can be used as teaching materials or as information sources for other environmental activities.

Examples of environmental projects done by secondary school students are listed in Case Study 7 (Boh and Kornhauser, 1992; Egneus and Tullberg, 1985, Kvam, 1985).

Conclusions

1. The main goals of contemporary environmental education are to develop (1) environmental, scientific and technological literacy, (2) experience in responsible environmental decision-making, and (3) environmental problem solving ability.

2. To accomplish these objectives, traditional classroom lectures are insufficient. Wider focus on communication and inquiry methods, the use of audiovisual aids, intensive information gathering activities, practical laboratory instruction, excursions and field work, will all contribute to successful environmental education outcomes.

3. There is no universal best approach for all environmental education situations, for all learners and for all countries. Teachers must select the most appropriate teaching styles, methods and techniques for any given situation.

4. Laboratory experiments, field work and excursions are of high importance but are often neglected. They can be performed with modest equipment and in relative simple surroundings. Several cost-effective opportunities exist.

5. Teacher training remains the most critical constraint in the improvement of environmental teaching methodologies and in the introduction of hands-on environmental science.
TEACHER TRAINING

Forms and strategies

An analysis of environmental teacher training programs (Boh, 1991; Boh and Kornhauser, 1992, Unesco-UNEP, 1986; Ware, 1992, Wilke, Peyton and Hungerford, 1987) shows that

(1) teacher training remains the key factor for improvement of environmental education;

(2) at least some pre-service and in-service environmental education for science teachers exist in most countries;

(3) the programs vary very much in all key characteristics: in format, in breadth, in scope, and in methodologies;

(4) many teachers who have received some traditional environmental education training are not well trained in interactive cooperative learning and problem-solving teaching methods and techniques;

(5) the number of effective environmental education programs for teachers is still limited;

(6) short courses that give only overviews of selected environmental topics or teaching methodologies cannot replace systematic environmental teacher training;

(7) there is a need for (a) guidelines in environmental teacher training programs at regional level, (b) assistance in their adaptation to local needs and (c) support for their implementation.

Pre-service training of teachers

This type of training depends on the national educational system, which is very different from country to country. However, in most countries, secondary science teacher education starts after 12 years of previous education, although 10 and 11 years are also found (Ware, 1992). In most systems, secondary school science teachers are educated in both science content and pedagogy, typically through a four year program.

At most teacher training colleges, a minimum environmental education is included in biology (fundamentals of ecology), and often also in chemistry and earth science. Sometimes, science teachers can take separate environmental courses, such as ecology with environmental protection, environmental chemistry, environmental pollution and waste treatment technologies,
chemical analysis in environmental science, health and sanitation, or advanced ecology courses such as plant ecology, zoo-ecology, fresh-water ecology, marine ecology, microbial ecology, and agricultural ecology. An increasing number of countries offer one or two years of post-graduate studies in environmental education for science teachers. Pre-service environmental education programs for teachers specializing in social sciences, humanities and arts are almost nonexistent.

There are cases where secondary school teachers still do not have any formal environmental education. Several countries are only now introducing the first environmental education courses into their teacher training programs. A study on secondary school science in developing countries (Ware, 1992) reveals that there are still some low-income countries, especially in the Sub-Saharan region, where secondary school science teachers only have the O-level science background possibly supported by some teaching courses. In some countries, teachers may have a science degree with no teacher training background. With many problems of this kind, the introduction of environmental education programs often remains a second priority.

Introducing environmental education into a pre-service teacher training may involve any one or combination of the three approaches:

1. infusing environmental foundational knowledge and teaching methods into existing courses;
2. developing a specific course in environmental education methods to be added to the curriculum (which already has some environmental science);
3. developing additional (upgraded or specialized) environmental courses to be added to the curriculum.

Much of the environmental education contents may be found in traditional disciplines, especially in the natural sciences, but in a non-environmental context. Theoretically, a relatively simple "environmentalization" of existing courses would fulfill both the general education and environmental education requirements in teacher training. In practice, this process is not easy, due to many constraints of coordination and cooperation, expertise, time and financing needed.

Still, with careful systematic planning and good cooperation, important gains can be made in environmental education by infusing environmental components into teacher training. The infusion may take place without compromising the quality or quantity of the existing courses. On the contrary, in most cases the quality of existing teacher training programs can be upgraded by the infusion of environmental components, especially if

1. the attention is focused on higher levels of environmental teaching (e.g. issue investigation and evaluation, action skills),
2. the methodological approaches are based on problem solving and decision making practices,
3. the practical experimental work is moved from "high science laboratories" with sophisticated equipment towards more "friendly and understandable" environmental processes, using locally available materials and resources;
4. the contents are adapted to understand and solve both local, regional, international and global environmental problems, and
5. the environmental education interlinks fundamental scientific knowledge with technological, economic, political, legal, and social processes in every day life situations.

Environmental material can be infused into all specialized courses in teacher training programs: biology, chemistry, physics, mathematics, earth science, agriculture, health and nutrition, technology, communications, economics, social sciences, religion, languages,
Teacher training

literature, arts, etc., as well as into general teacher training programs, such as pre-school education methodologies, general classroom teaching, methodology of science teaching, pedagogy, psychology, and others.*

Changing teacher training curricula means changing the curriculum of the teacher training institution. In order to incorporate an environmental dimension in teacher training programs, not only changes in curriculum are needed, but also changes in textbooks, infrastructure, budget, and personnel. As a first educational priority the environmental education of teacher trainers, both in pre-service and in-service training, has to be upgraded and improved.

In-service environmental training

This type of training can have various forms: (1) graduate and continuing education courses, (2) seminars and workshops, (3) environmental summer schools, (4) environmental research field projects for teachers, (5) environmental research courses at research institutes, (6) conferences, (7) lectures and demonstrations in environmental centers, (8) correspondence courses, (9) distance-learning programs through TV, radio and video, (10) self-education through environmental manuals, methodological handbooks, teacher’s guides and audio-visual materials.

Implementation of in-service environmental training follows one of the following three main organizational models:

a) The cascade model follows a hierarchical structure (training of trainers of trainers...). The cascades may be, for instance, environmental specialists - university staff - environmental education administrators - teachers in environmental learning centers or teacher training institutions - classroom teachers. The main advantage of this model is a strong multiplying effect. However, there is also a danger of knowledge erosion - if not properly transferred, the quality of training decreases at each level of the cascade.

b) The peer training model utilizes selected faculty members of the educational institution as trainers. These are given intensive environmental training in order to be able to conduct peer training sessions for teachers at their own and other institutions.

c) The modular training model is based on independent learning by each individual teacher, either alone or in a group of loosely organized trainees.

In an educational change, teacher training is of crucial importance. The study of secondary school science in developing countries (Ware, 1992) stresses the importance of in-service teacher training. The same conclusion can be applied to environmental teacher training.

The large number of insufficiently prepared teachers now in service requests the introduction of appropriate continuing environmental education be made available to all

* Some detailed examples of infusing environmental education into teacher training programs are given in Strategies for the Training of Teachers in Environmental Education (Wilke, Peyton and Hungerford, 1987), pp. 82 - 102, and in An Environmental Education Approach to the Training of Elementary Teachers: A Teacher Education Program (Hungerford, Volk, Dixon, Marchinkowski, Sia and Jamaloudin, 1988), pp. 17-60.
teachers, and especially to science teachers. Introduction of new environmental curricula, textbooks, equipment or environmental kits all require parallel in-service teacher training. Teachers need to be instructed on:

1) how to use the new instructional environmental materials, (textbooks, audiovisuals),
2) how to introduce new methodological approaches to environmental teaching,
3) how to use and maintain new environmental equipment and kits,
4) how to organize and perform experimental activities, excursions, and project research activities for students, and
5) how to participate in environmental problem solving and citizenship actions.

In a study on how to improve teaching, Verspoor and Leno (1986) recommend the following approaches in teacher training:

1) provide locally available and permanent in-service education,
2) design workshops based on teacher’s needs and knowledge,
3) create systems to support and supervise teachers, and
4) find ways to motivate and reward teachers.

The in-service training is only feasible when teachers are willing and able to devote the necessary time and effort to the additional training. For the improvement of in-service teacher training practices Posch (1991) proposes the following strategies:

1) teachers should become not only recipients but active planners and developers of their in-service education,
2) the practice of holding in-service training at education centers outside the school ought to be supplemented by in-service training within schools, where testing of innovations can be performed,
3) traditional individual in-service training should be supplemented by giving training to groups of teachers or the entire teaching staff of the school,
4) the practice of school management "allowing" in-service education should be replaced by an active school in-service education policy promoted by the principal and supported by the administrative bodies,
5) counseling, technical assistance and incentives should be promoted, which stimulate teachers to participate actively in in-service training, to implement innovations in environmental teaching independently, and test and support them institutionally.

Wilke, Peyton and Hungerford (1987) define an effective environmental teacher training program as any program that results in the following teacher competencies*:

a) foundational competencies in professional education
b) additional competencies in environmental education contents such as:
   1. Ecological foundations
   2. Conceptual environmental awareness
   3. Environmental issue investigation and evaluation
   4. Environmental action skills.

* Detailed explanation of competencies required for an effective environmental educator is given in the document Strategies for the Training of Teachers in Environmental Education, chapter III, by the same authors.
Which environmental skills are essential for secondary school science teachers?

Within the Unesco-UNEP International Environmental Education Program (1986), two modules for pre-service and in-service training of secondary school science teachers and supervisors were prepared. Both documents contain sections with basic concepts and essential environmental knowledge which are considered necessary requirements for any science teacher.

The modules have a different structure. The environmental content in pre-service training is built around the five themes: energy, ecosystems, resources, food and population. The environmental content for in-service training is organized in two main sections: the environment, and environmental problems.

Table 6 summarizes and compares the main topics of the two modules (numbering refers to the module texts).

Table 6: A comparison of UNESCO pre-service and in-service teacher training modules in environmental education

<table>
<thead>
<tr>
<th>PRE-SERVICE SCIENCE TEACHER TRAINING MODULE</th>
<th>IN-SERVICE SCIENCE TEACHER TRAINING MODULE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unesco-UNEP, 1986 (Fensham, Hunwick and Jacobson)</td>
<td>Unesco-UNEP, 1986 (Cortes, Galvante, Rodriguez, Basa)</td>
</tr>
</tbody>
</table>

1) ENERGY
- Kinds of change and types of energy
- Mechanisms of energy transfer
- The characteristics of energy transfer
- The availability of energy for work
- Units of energy

2. Energy flow in the abiotic component of the earth ecosystem
   - Earth's ultimate source of energy
   - Factors affecting energy flow in the earth ecosystem
   - Water cycle and its role in energy flow
   - Energy transformations and losses
   - Energy from the earth's interior

3. Energy flow in the biotic component of the earth ecosystem
   - Photosynthesis
   - Respiration
   - Trophic levels
   - The 10 per cent law (energy losses through the food chain)

* Another example of environmental education program for secondary school teacher training, designed by environmental specialists from Asia, is given in Case Study 8.
| 2) ECOSYSTEM | 1. Structure and function of an ecosystem  
| Types of ecosystems  
| Habitat and ecological niche  
| Concept of limiting factors  
| 4. Materials flow in the biogeochemical cycles  
| Earth processes and their role in nutrient flow  
| The water cycle and its role in nutrient flow  
| 5. The gaseous cycles  
| Carbon cycle  
| Nitrogen cycle  
| Oxygen cycle  
| Sedimentary cycles  
| Phosphorus  
| Sulfur  
| 3) RESOURCES | 7. Human intervention in natural resources  
| Human activities that effect energy flow in the earth ecosystem  
| Increased combustion and carbon dioxide production  
| Smog, soot and other particulate matter  
| Ozone  
| Concentration of population, heat sink and wind flow in cities  
| Human activities that affect materials flow in the earth ecosystem  
| Air pollution (pollutants and polluters)  
| The human ecosystem  
| 4) FOOD PRODUCTION | 6. Population dynamics  
| Density  
| Natality, mortality and dispersal  
| Age structure  
| Population growth  
| Regulation of population size  
| Natural selection and evaluation  
| 6) HUMAN POPULATION | Growth and control of human population  
| Natality, mortality and dispersal  
| Age structure  
| Population growth  
| Regulation of population size  
| Natural selection and evaluation  
| Controlling population growth |
B) ENVIRONMENTAL PROBLEMS

1. Four major dimensions of environmental problems
   - The physical, economic and social consequences of environmental problems
   - The geographical scale of environmental problems
   - The time scale of environmental problems
   - The socio-economic systems affected by environmental problems

2. Major causes of environmental problems
   - Rapid population growth
   - Decreasing surface area per capita
   - Food shortage
   - Water shortage
   - Energy crisis
   - Scarcity of the earth’s materials
   - New problems from science and technology
     - Medical technology
     - Agricultural technology
     - Energy technology
     - Food technology
     - Materials substitution technology
   - Development and industrialization result in new problems
     - Cost of development
     - Development in developing countries
     - Increased waste production and pollution
     - Cost of pollution
     - Concentration of human population (urbanization)
     - Unemployment and poverty
     - Concentration of wastes
     - High incidence of diseases
     - Malnutrition
     - Conflicting land uses

3. Broad-based measures towards the solution of environmental problems
   - Control of population growth: birth control through education, family
   - Planning and socio-economic measures
   - Using science and technology to solve environmental problems
   - Expanding and improving traditional food sources
   - Developing new and unconventional food sources
   - Treatment of malnutrition
   - Air pollution abatement
   - Water pollution abatement
   - Recycling
   - Planning human intervention into the natural processes
As typical for most of the traditional environmental education curricula, both programs adequately cover the basic concepts of ecology. In addition, the in-service module discusses environmental problems and shows some of the possible pollution abatement strategies and other possibilities for resolving environmental issues. This is given less emphasis in the pre-service module.

However, vis-a-vis the current environmental problems and their possible solutions, this is not sufficient. For high-quality environmental science education, further updating/improving of contents (as well as teaching methodology) is needed, such as:

1. introducing new environmental concepts and issues,
2. increasing the emphasis on different approaches for solving environmental problems (large scale solutions and individual contributions),
3. better adaptation of curricula to the local characteristics, needs and priorities.

For example, the following environmental themes might be added or improved, illustrating both problems and possible solutions:

**New concepts and technologies for environmental preservation**

- Waste minimization concepts (related to all human activities)
- Energy conservation concepts (related to all human activities)
- Alternative sources of energy
- Environmentally-sound management of renewable/non-renewable biodegradable/non-biodegradable materials
- Elimination/replacement of hazardous chemicals (related to all human activities)
- New "environmentally friendly" natural and synthetic materials
- Clean and closed cycle technologies
- Genetic engineering, biotechnology and the environment
- Contemporary waste treatment processes and technologies (treatment of gases and vapors, waste waters and solid wastes; hazardous waste, radioactive waste)
- Environmentally-sound agricultural cultivation practices and agrochemicals
- Unconventional food and fuel plants

**General environmental issues**

- Science and technology for simultaneous rapid economic development and environmental protection (how to make environmentally sound decisions)
- Cultural and individual constraints in the implementation of environmental protection (how to deal with and overcome them)
- Effects of environmental degradation on physical and mental health (environmentally-related diseases)
Teacher training

- Environmentally sound consumer choices (individual's contribution to environmental conservation)
- How to improve the most intimate environment - the home (energy, materials, indoor pollution (smoking, noise), food and nutrition, aesthetic appearance, household wastes, etc.)

Global environmental problems

- Global warming (greenhouse effect), acid rain and stratospheric ozone depletion as typical consequences of intensive industrialized lifestyles
- Destruction of natural habitats (special emphasis on forests) - reasons, consequences and strategies for their conservation
- Wildlife extinction and protection of species

Specific environmental topics for teachers in the poorest countries

- Environmental education for prevention of water borne and other environmentally-related diseases
- Alternative systems and techniques for improvement of sanitation, waste management and waste treatment in poor communities
- Improving efficiency of rural cooking and heating systems
- Alternative fuel sources
- Improving agricultural practices
- Improving animal breeding practices
- Alternative food plants and better nutritional habits

For all science teachers: improving science teaching through environmental education

- Science teaching about the environment (enriching the teaching of scientific concepts, phenomena and laws by linking them to the processes in nature and every day life situations; making the students curious and interested in natural phenomena and human activities affecting the environment)
- Science teaching in the environment (using natural and urban environments as a laboratory for discovery, observation, demonstration, experimenting and testing of science concepts)
- Science teaching for environmentally-sound development, improvement of living conditions, abatement of environmental problems and nature conservation.

The methodology of environmental education

The environmental education methodology courses are crucial to train fully competent teachers. In several cases, teachers acquire a relatively good general environmental knowledge during their studies, but they lack the methodological skills to apply and use it in creative ways during the teaching process. With the introduction of new environmental education concepts, where teachers have additional responsibilities for preparing their students for solving
environmental problems, the importance of methodological components and the demands for them are even greater.

In spite of the recognized needs, very few data on teacher training in environmental education methods are available, and only a few comprehensive methodological textbooks or manuals are available to assist teachers or course developers.

Within the Unesco-UNEP program for the training of teachers in environmental education, a methodological course has been prepared, which attempts to fulfill the new environmental education requirements. The major headings of the environmental teaching methods program are given in Table 7.

Table 7: Main topics in the Unesco-UNEP environmental education methodology course for teachers (Wilke, Peyton and Hungerford, 1987)

<table>
<thead>
<tr>
<th>MAIN SECTION</th>
<th>TOPICS</th>
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<tr>
<td>Environmental philosophy</td>
<td>The need for environmental education,</td>
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<td></td>
<td>The logic behind a holistic view of the environment</td>
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<td></td>
<td>The goals of environmental education</td>
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<td></td>
<td>The similarities and differences of environmental education and other disciplines</td>
</tr>
<tr>
<td></td>
<td>The role of experimentalism in environmental education</td>
</tr>
<tr>
<td></td>
<td>The need for highly skilled teachers</td>
</tr>
<tr>
<td>The learner and environmental education</td>
<td>Consideration of both, physical and intellectual development in planning environmental education</td>
</tr>
<tr>
<td></td>
<td>Characteristics of cognitive knowledge with emphasis on concept development</td>
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<td></td>
<td>Characteristics of cognitive processes</td>
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<td></td>
<td>Characteristics of attitudes and values</td>
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<tr>
<td></td>
<td>Relationships between knowledge, skills, values and human behavior</td>
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<td></td>
<td>Transfer of learning and implications for environmental education</td>
</tr>
<tr>
<td></td>
<td>Implications of special student populations for environmental education (disadvantaged, gifted, disabled)</td>
</tr>
<tr>
<td>Curriculum development in environmental education</td>
<td>Key foundational components in environmental education</td>
</tr>
<tr>
<td></td>
<td>Goals - by level - for environmental education curricula</td>
</tr>
<tr>
<td></td>
<td>Analyzing goal components</td>
</tr>
<tr>
<td>Curriculum models</td>
<td>Advantages and disadvantages of environmental education as a monodisciplinary curriculum</td>
</tr>
<tr>
<td></td>
<td>Advantages and disadvantages of infused interdisciplinary curriculum</td>
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<td></td>
<td>Problems and strategies associated with the implementation and evaluation of infused environmental curriculum</td>
</tr>
<tr>
<td></td>
<td>Case studies illustrating successful environmental education programs - both monodisciplinary and interdisciplinary</td>
</tr>
<tr>
<td>Teacher training</td>
<td></td>
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<tr>
<td>------------------</td>
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</tr>
</tbody>
</table>
| Preparing for instruction | Rationale for using syntactically sound instructional model  
The general teaching model and its permutations (objectives, preassessment, instruction, postassessment)  
Strategies for the production of objectives, pretests, instructional sequences, and posttests. |
| Methods of teaching environmental awareness | The awareness level as a goal  
Implications of awareness education research for environmental education  
Teaching methods in awareness instruction:  
- case study analysis,  
- simulations,  
- panel discussions and formal debates,  
- films and other audio-visual modes. |
| Methods of teaching investigation skills | Goals of the investigation and evaluation level  
Implications of research in this field for environmental education  
Teaching methods for skills development and use. |
| Methods of affective education | Goals of affective education  
Benefits of affective education and common objectives  
Research in this field and implications for environmental education  
Teaching strategies appropriate for use in affective education:  
- case studies,  
- issue position simulation activities  
- episodic/situational values clarification activities  
- moral dilemmas, etc.  
Performance characteristics of an effective affective teacher |
| Methods of teaching citizenship action skills | Goals of citizenship action training and application  
Research in this field and the implications for environmental education  
The model of an environmental action  
Appropriate teaching strategies for the teaching of  
- persuasion skills,  
- consumer skills,  
- political action skills,  
- legal action skills.  
Applying and evaluating citizenship action strategies with receiver groups. |
| Resource utilization | Rationales for using field experiences(e.g. ecological knowledge, issue investigation and evaluation)  
Local and regional resources available for use in environmental education  
Human resources available in environmental education  
Types of resource inventories available for use in environmental education  
Inventorying procedures for a resource survey in environmental education  
Distribution of resource information  
Guidelines and instructional strategies for resource utilization |
Teacher training

| Selection, implementation and evaluation of environmental programs | Environmental programs available for adoption or adaptation into existing school programs |
| | Criteria for the selection of environmental programs |
| | Implementing environmental education curricula |
| | Curriculum evaluation |

In addition to the above listed methodological instructions, a novice science teacher will need help and support on specific natural science-related methods and techniques, e.g.:

**Enriching classroom lectures with samples and illustrations**

- Which materials can be used for illustration of environmental concepts and issues (e.g. plants, animals, consumer products, waste materials, advertisements, newspaper articles, photographs, maps, slides, video, etc.)
- How to include them into teaching.

**Classroom and laboratory experiments**

How to:
- prepare and conduct effective demonstration experiments in a classroom
- design and organize laboratory environmental experiments for students
- select (buy) equipment and chemicals for environmental education experiments
- build effective low-cost equipment
- design effective low-cost environmental experiments
- maintain/repair equipment
- introduce ethics and safety in laboratory experiments

**Field work**

How to:
- use local environment and natural resources as an "always available laboratory" for environmental teaching, as well as for science teaching
- plan and organize field work activities:
  (a) conducting visits (observation, asking questions)
  (b) collecting samples for further work or use at school
  (c) performing field experiments (e.g. measurements of abiotic factors, chemical analysis, biological determination, etc.)
- apply environmental ethics and safety at field work

**Students seminars and research projects in environmental education/natural sciences interlink**

How to:
- guide students towards interesting environmental topics for their seminar or project work
- organize and supervise students activities:
  (a) collecting data (using all possible sources)
(b) analyzing data, organizing them into tables, and prepare tree and modular structures
(c) designing research hypotheses
(d) testing research hypotheses (with information methods or with practical/experimental work)
(e) presenting the results to the colleagues
(f) using the results in solving environmental problems (or preserving the environment)

- provide the necessary materials and equipment (searching for innovative low-cost solutions)
- establish links with local communities, industries, farms, and research institutions to help students in collecting or evaluating data, searching for sample materials, or performing experimental work. Environmental secondary school projects, supervised by science teachers or by mixed teams of teachers and industry/agriculture/research specialists, are in some countries a well established practice.

**Conclusions**

1) In most of the countries there are at least some basic environmental concepts in pre-service and/or in-service training of science teachers, though there are cases with no environmental teacher training at all.

2) The major teacher training deficiencies seem to be in contemporary methodological approaches to environmental education, which stress active learning, cross-disciplinarity, adaptation to local conditions, and orientation towards understanding and solving environmental problems.

3) Most of the traditional curricula for training of science teachers cover only the basic concepts of ecology and briefly discuss environmental problems. New environmental concepts and issues have to be brought into environmental teacher training, such as waste minimization and energy conservation concepts; new materials, technologies and agricultural practices; global environmental issues; and possible solutions and actions for solving environmental problems.

4) In a pre-service teacher training, environmental education can be taught as an integral course or infused into all specialized and general teacher training subjects. By infusing environmental components, the quality of existing teacher training programs can be significantly upgraded.

5) While there is a strong need to reform pre-service environmental teacher training, an even more urgent priority seems to be the introduction of appropriate continuing in-service environmental education, adapted to local needs and resources.

6) As the very first educational priority, the environmental education of teacher educators, for both pre-service and in-service training, has to be upgraded and improved.

7) In each country, mechanisms need to be introduced to motivate, support and supervise environmental teacher training and the quality of environmental teaching at schools.
CASE STUDIES

Case study 1:
An environmentally related chemistry program for high schools

ChemCom - CHEMISTRY IN THE Community
A project of the American Chemical Society (ACS, 1993)

Chemistry in the Community was developed by the American Chemical Society as a team work of several high school, college and university teachers, chemists from industry and government. The project was financed from the National Science Foundation and ACS sources.

ChemCom started in 1982 as a response to relatively low scientific literacy of average US citizens, who did not choose a scientific career, and was therefore designed primarily to help students (1) realize the important role that chemistry plays in personal and professional lives, (2) use chemistry knowledge to make informed decisions about issues involving science, technology and environment, and (3) develop a lifelong awareness of both the potential and limitations of science and technology.

The first edition was released in 1988, after six years of development, testing and revision. At present, it has been successfully implemented and widely used by chemistry teachers in US high schools. The second edition (1993) maintains the overall structure and approach of the 1988 edition, but in addition provides updated information as well as improvements based on suggestions from classroom experience.

Most of the ChemCom topics are introduced through or derive from the environmental issues concerning students' every day lives. The methodological approaches support the development of a basic scientific vocabulary, understanding of scientific concepts, thinking skills, and encourage student's practical activities including laboratory exercises, decision-making and problem-solving.

The main ChemCom topics, analyzed and structured with emphasis on environmental components, scientific concepts and practical student activities, are summarized in Table 8*

* For additional information on ChemCom see ACS, 1993; Ware, 1989 and 1992.
### Table 8: ChemCom analysis: environmental components, scientific concepts and practical activities

#### Chapter 1: SUPPLYING OUR WATER NEEDS

<table>
<thead>
<tr>
<th>MAIN CHAPTERS</th>
<th>ENVIRONMENTAL COMPONENTS</th>
<th>SCIENTIFIC CONCEPTS</th>
<th>PRACTICAL WORK</th>
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</thead>
<tbody>
<tr>
<td>THE QUALITY OF WATER</td>
<td>Fish kill causes water emergency in riverhood</td>
<td>Measurement and the metric system</td>
<td>Information gathering</td>
</tr>
<tr>
<td></td>
<td>Water and health</td>
<td>The hydrologic cycle</td>
<td>Laboratory work: Foul water (oil-water separation, sand filtration, charcoal adsorption/filtration, distillation)</td>
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<tr>
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<td>Water uses</td>
<td>Three states of water</td>
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<td>A water treatment plant</td>
<td>Water distribution on Earth</td>
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<tr>
<td>A LOOK AT WATER AND ITS CONTAMINANTS</td>
<td>Meeting raises fish kill concerns</td>
<td>Physical properties of water</td>
<td>Laboratory work: Classification of water-containing mixtures (suspension, colloid, solution); Water testing: Iron(III), Calcium, Chloride, and Sulfate ion tests</td>
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<tr>
<td></td>
<td>Pure and impure water</td>
<td>Mixtures and solutions</td>
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<td></td>
<td>The riverhood mystery</td>
<td>Matter at the micro level</td>
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<td></td>
<td></td>
<td>Symbols, formulas, and equations</td>
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<td></td>
<td></td>
<td>Electrical nature of matter</td>
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<td>Cations and anions</td>
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</tr>
<tr>
<td>INVESTIGATING THE CAUSE OF THE FISH KILL</td>
<td>Oxygen supply and demand in water ecosystems</td>
<td>Solubility</td>
<td>Laboratory work: Solvents (solubility of different solutes in different solvents)</td>
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<td></td>
<td>Acid contamination</td>
<td>Solution concentration</td>
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<td>Heavy metal ion contamination</td>
<td>Temperature and gas solubility</td>
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<td>Molecular substances in the river</td>
<td>Acids and bases</td>
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<td>Ions and ionic compounds</td>
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<td></td>
<td>Dissolving ionic compounds</td>
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<tr>
<td></td>
<td></td>
<td>Heavy metal ions</td>
<td></td>
</tr>
<tr>
<td>WATER PURIFICATION AND TREATMENT</td>
<td>Fish kill remains a mystery</td>
<td>Hard and soft water</td>
<td>Laboratory work: Water softening</td>
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<tr>
<td></td>
<td>Natural water purification</td>
<td>Minerals in hard water</td>
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<td></td>
<td>Municipal water purification</td>
<td>Soaps</td>
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<td></td>
<td>Sewage treatment plant</td>
<td>Chlorination chemicals</td>
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<td></td>
<td>Chlorine as water disinfectant</td>
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<tr>
<td>FISH KILL - WHO PAYS</td>
<td>Fish kill cause found</td>
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<td>Role playing: town council meeting, power company officials, scientists, engineers, chamber of commerce, sanitation commission, taxpayer association</td>
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</tbody>
</table>
## Chapter 2: CONSERVING CHEMICAL RESOURCES

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<th>SCIENTIFIC CONCEPTS</th>
<th>PRACTICAL WORK</th>
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<tbody>
<tr>
<td>USE OF RESOURCES</td>
<td>Using things up Resources and waste Renewable resources Nonrenewable resources Disposing of things Municipal solid waste Consuming resources</td>
<td>The law of conservation of matter. Atoms Chemical equations</td>
<td>Laboratory work: Changing properties of metals; Reaction between nitric acid and copper metal</td>
</tr>
<tr>
<td>WHY WE USE WHAT WE DO</td>
<td>Corrosion Preserving the past. restoring</td>
<td>Physical and chemical properties of materials Chemical elements The periodic table Chemical reactivity What determines properties</td>
<td>Laboratory work: Classification of elements (metals, nonmetals, metalloids); Metal reactivities</td>
</tr>
<tr>
<td>CONSERVATION IN THE NATURE</td>
<td>Sources of resources Conservation is nature's way Conservation must be our way Recycling</td>
<td>Balancing equations Atom, molecule, ion Molar mass</td>
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<tr>
<td>METALS: SOURCES AND RESOURCES</td>
<td>Copper: sources and uses Mining Alternatives to metals</td>
<td>The copper cycle Metals from ores Percent composition Metal reactivity series Future materials Ceramics</td>
<td>Laboratory work: producing copper</td>
</tr>
<tr>
<td>HOW LONG WILL THE SUPPLY LAST</td>
<td>Metal reserves: three projections Options and opportunities</td>
<td>Characteristics of chemical elements and their usage</td>
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#### Chapter 3: PETROLEUM - TO BUILD OR TO BURN

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<th><strong>SCIENTIFIC CONCEPTS</strong></th>
<th><strong>PRACTICAL WORK</strong></th>
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<tbody>
<tr>
<td>PETROLEUM IN OUR LIVES</td>
<td>Petroleum based products Petroleum and our future Who has got the oil</td>
<td>Crude oil and related materials Hydrocarbons Petroleum refining Petroleum molecules Chemical bonding Tetrahedral shape of methane molecule Alkane boiling points Isomers</td>
<td>Laboratory work: Viscosity and density measurements. Chemical models: three-dimensional ball-and-stick models of alkane molecules.</td>
</tr>
<tr>
<td>USEFUL MATERIALS FROM PETROLEUM</td>
<td>Materials from petrochemicals Safety in polymerization</td>
<td>Double bond Alkenes, cyclohexane, benzene Molecules containing oxygen Petrochemicals and polymerization</td>
<td>Chemical models: building three-dimensional models of alkenes Laboratory work: methyl acetate synthesis</td>
</tr>
<tr>
<td>ALTERNATIVES TO PETROLEUM CHOOSING PETROLEUM FUTURE</td>
<td>Alternative energy sources Biomass Confronting the issues</td>
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</table>
## Chapter 4: UNDERSTANDING FOOD

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<th>SCIENTIFIC CONCEPTS</th>
<th>PRACTICAL WORK</th>
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<tbody>
<tr>
<td>FOODS: TO BUILD OR TO BURN</td>
<td>Nutritional imbalances</td>
<td>Calorimetry</td>
<td>Calculations: energy content of foods in diet planning</td>
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<td>FOOD AS ENERGY</td>
<td>Dimensions of hunger</td>
<td>Energy expenditures</td>
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<td>Why hunger</td>
<td>Carbohydrates</td>
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<td>Fats</td>
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<tr>
<td>FOODS: THE BUILDER MOLECULES</td>
<td>Proteins in the diet</td>
<td>Foods as chemical reactants</td>
<td>Laboratory work: Milk analysis</td>
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<td>Limiting reactants</td>
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<td>Proteins and amino acids</td>
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<tr>
<td>OTHER SUBSTANCES IN FOOD</td>
<td>Vitamins and minerals in the diet</td>
<td>Vitamins</td>
<td>Laboratory work: Vitamin C determination in foods;</td>
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<td>Food quality</td>
<td>Titration</td>
<td>Iron in foods.</td>
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<td>Benefits and risks of food additives</td>
<td>Minerals</td>
<td>Consumer analysis: ingredients of food products</td>
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<tr>
<td>NUTRITION AROUND THE WORLD</td>
<td>Diet analysis and meals around the world</td>
<td>Food additives</td>
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</table>

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### Chapter 5: NUCLEAR CHEMISTRY IN OUR WORLD

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<th>PRACTICAL WORK</th>
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<td>ENERGY AND ATOMS</td>
<td>Public understanding of atomic energy</td>
<td>Energy and atoms</td>
<td>Laboratory work:</td>
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<td>Radiation therapy</td>
<td>Different kinds of radiation (light, x-rays)</td>
<td>Radioactivity;</td>
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<td>Nuclear radiation</td>
<td>The black box:</td>
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<td>Architecture of atoms</td>
<td>Isotopic pennies</td>
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<td>Isotopes in nature</td>
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<td>RADIOACTIVE DECAY</td>
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<td>Natural radioactive decay</td>
<td>Laboratory work:</td>
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<td>Half-life: a radioactive clock</td>
<td>Measuring radiation;</td>
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<td>Radiation detectors</td>
<td>Shielding effect.</td>
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<td>Artificial radioactivity</td>
<td>Cloud chambers.</td>
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<td>Simulation: Radioactive decay (with pennies)</td>
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<tr>
<td>NUCLEAR ENERGY: LIVING WITH BENEFITS</td>
<td>Benefits of radioisotopes</td>
<td>Splitting the atom</td>
<td>Processing survey</td>
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<tr>
<td>AND RISKS. SEPARATING FACT FROM FICTION</td>
<td>Radiation damage</td>
<td>Chain reactions</td>
<td>information: public</td>
</tr>
<tr>
<td></td>
<td>Radiation exposure standards</td>
<td>Nuclear energy</td>
<td>understanding of nuclear</td>
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<tr>
<td></td>
<td>Radon at homes</td>
<td>Nuclear fusion</td>
<td>phenomena</td>
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<td></td>
<td>Nuclear waste</td>
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<td></td>
<td>Catastrophic risk: a plant accident</td>
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</table>
## Case Studies

### Chapter 6: CHEMISTRY, AIR AND CLIMATE

<table>
<thead>
<tr>
<th>MAIN CHAPTERS</th>
<th>ENVIRONMENTAL COMPONENTS</th>
<th>SCIENTIFIC CONCEPTS</th>
<th>PRACTICAL WORK</th>
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</thead>
<tbody>
<tr>
<td>LIVING IN A SEA OF AIR</td>
<td></td>
<td>Air</td>
<td>Laboratory demonstration: Gases</td>
</tr>
<tr>
<td>INVESTIGATING THE ATMOSPHERE</td>
<td>The atmosphere</td>
<td>Avogadro’s law</td>
<td>Laboratory work: Preparation of oxygen gas and carbon dioxide gas. Gas tests.</td>
</tr>
<tr>
<td></td>
<td>Air pressure and weather changes</td>
<td>Molar volume</td>
<td>Temperature-volume relationships.</td>
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<td></td>
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<td>Air pressure</td>
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<td></td>
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<td>Boyle’s law</td>
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<td>Temperature scale</td>
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<td>Kinetic energy</td>
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<td></td>
<td></td>
<td>Ideal gases</td>
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<tr>
<td>ATMOSPHERE AND CLIMATE</td>
<td>Earth’s energy balance</td>
<td>Solar radiation</td>
<td>Laboratory work: Carbon dioxide levels in normal air, exhaled air, air from</td>
</tr>
<tr>
<td></td>
<td>The Earth surface</td>
<td>Thermal properties of materials</td>
<td>combustion</td>
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<td></td>
<td>The carbon cycle</td>
<td>Heat capacity</td>
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<td></td>
<td>Urban horticulture</td>
<td>Ozone reactions</td>
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<td></td>
<td>Trends in carbon dioxide levels</td>
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<td></td>
<td>Off in the ozone</td>
<td></td>
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<tr>
<td>HUMAN IMPACT ON AIR WE</td>
<td>To exist is to pollute</td>
<td>Major pollutants</td>
<td>Laboratory work: Cleansing air (electrostatic precipitator, wet scrubbing).</td>
</tr>
<tr>
<td>BREATHE</td>
<td>Air pollution</td>
<td>Methods and technologies for particle emissions control</td>
<td>Acid rain</td>
</tr>
<tr>
<td></td>
<td>Smog: hazardous to your health</td>
<td>Photochemical smog reactions</td>
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<td></td>
<td>US pollutant standards</td>
<td>Controlling automobile emissions (catalytic converter)</td>
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<td></td>
<td>Industrial emissions of particulates</td>
<td>Chemistry of acid rain pH</td>
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<td>Traffic</td>
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<td></td>
<td>Air pollution control</td>
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<td>IS AIR A FREE RESOURCE</td>
<td>Air pollution control: a success</td>
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<td>Air pollution costs</td>
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</table>
## Chapter 7: HEALTH - YOUR RISKS AND CHOICES

<table>
<thead>
<tr>
<th>MAIN CHAPTERS</th>
<th>ENVIRONMENTAL COMPONENTS</th>
<th>SCIENTIFIC CONCEPTS</th>
<th>PRACTICAL WORK</th>
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</thead>
<tbody>
<tr>
<td>RISKS AND PERSONAL DECISION MAKING</td>
<td>Making judgments about the risk</td>
<td>Human diseases</td>
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<td>Medical technologies</td>
<td></td>
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<tr>
<td>YOUR BODY'S INTERNAL CHEMISTRY</td>
<td>Balance and order: keys to life</td>
<td>Elements in the human body</td>
<td>Laboratory demonstration: Enzymatic decomposition of hydrogen peroxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cellular chemistry</td>
<td>Laboratory work: Enzyme activity (pepsin, amylase)</td>
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<td></td>
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<td>How enzymes work</td>
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<td></td>
<td></td>
<td>Release and storage of energy</td>
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</tr>
<tr>
<td>ACIDS, BASES AND BODY CHEMISTRY</td>
<td>Structure and function of acids and bases</td>
<td>Structure and function of acids and bases</td>
<td>Laboratory work: Preparation and testing of buffers</td>
</tr>
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<td></td>
<td></td>
<td>Strengths of acids and bases</td>
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<td></td>
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<td>Buffers</td>
<td></td>
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<td></td>
<td></td>
<td>Body pH balance</td>
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</tr>
<tr>
<td>CHEMISTRY AT THE BODY'S SURFACE</td>
<td>Keeping clean with chemistry</td>
<td>Polarity and solubility</td>
<td>Laboratory activity: Sunscreens (screening abilities of creams having different sun protection factors). Chemistry of hair.</td>
</tr>
<tr>
<td></td>
<td>Protecting the skin from the sun</td>
<td>Soaps and detergents</td>
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<tr>
<td></td>
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<td>Structure of human skin</td>
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<td>Vitamin D</td>
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<td></td>
<td></td>
<td>Hair structure</td>
<td></td>
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<td></td>
<td></td>
<td>Chemistry of hair styling</td>
<td></td>
</tr>
<tr>
<td>CHEMICAL CONTROL: DRUGS AND TOXINS IN THE HUMAN BODY</td>
<td>Effects of alcohol Drugs</td>
<td>Drug function</td>
<td>Laboratory activity: Smoking (smoke particles trapping, Euglena test)</td>
</tr>
<tr>
<td>ASSESSING RISKS</td>
<td>Drugs AIDS Cigarette smoking Risks from alcohol and other drugs</td>
<td>Aspirin Detoxification and immune response</td>
<td></td>
</tr>
</tbody>
</table>
## Chapter 8: THE CHEMICAL INDUSTRY: PROMISE AND CHALLENGE

<table>
<thead>
<tr>
<th>MAIN CHAPTERS</th>
<th>ENVIRONMENTAL COMPONENTS</th>
<th>SCIENTIFIC CONCEPTS</th>
<th>PRACTICAL WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>A NEW INDUSTRY FOR RIVERHOOD</td>
<td>Industry as a social partner</td>
<td>Basic needs met by chemistry</td>
<td>Class activity: presentation of chemical processes and industries</td>
</tr>
<tr>
<td></td>
<td>Positive and negative effects of chemical industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AN OVERVIEW OF THE CHEMICAL INDUSTRY</td>
<td>Organization of a chemical corporation</td>
<td>From raw materials to products</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>From test tubes to tank cars</td>
<td></td>
</tr>
<tr>
<td>THE CHEMISTRY OF SOME NITROGEN BASED PRODUCTS</td>
<td>Fertilizers</td>
<td>Fertilizer's chemical roles Nitrogen cycle Nitrogen fixation Electronegativity and oxidation state Industrial nitrogen compounds Explosives</td>
<td>Laboratory activity: Fertilizer (anions and cations identification). Phosphate ion in a fertilizer solution.</td>
</tr>
<tr>
<td>CHEMICAL ENERGY AND ELECTRICAL ENERGY</td>
<td>Metals in the marketplace Planning for an industry</td>
<td>Electrochemistry Oxidation and reduction Charging and discharging a car battery Industrial electrochemistry</td>
<td>Laboratory work: Voltaic cells: Electroplating</td>
</tr>
<tr>
<td>CHEMICAL INDUSTRY PAST, PRESENT AND FUTURE</td>
<td>The evolution of chemical technology</td>
<td>Future developments</td>
<td></td>
</tr>
</tbody>
</table>
Case study 2:
An environmentally related integrated science program for junior secondary schools

FACETS - FOUNDATIONS AND CHALLENGES TO ENCOURAGE TECHNOLOGY-BASED SCIENCE
(National Science Foundation and American Chemical Society)

FACETS is an integrated science/technology/society issue-based curriculum for seventh and eighth grade students, at present still in development and field testing stage. The first draft of the seventh grade modules was prepared in summer 1991, followed by draft eighth grade modules during the school year 1991/92. The production of the final texts is planned to be completed by the end of the academic year 1993/94.

The main emphasis of the project is on acquiring problem-solving skills that can be used in any situation. The program is designed as a series of dynamic modules which are constantly updated to address new concerns, issues and scientific findings. Students and teachers are expected to use the modules as "jumping off" points for investigating fascinating issues in science, technology and society. There is no formal scope and sequence of science concepts - they are taught in direct relation to the issue under investigation. However, the authors of FACETS assume that by the end of the year, students can acquire sufficient knowledge, science skills, and strategies for solving problems, be able to recognize how scientific knowledge relates to the real world.

FACETS consists of 24 modules (12 for each grade), listed in Table 9.

Table 9: The structure of FACETS curriculum (Field test materials, 1991)

<table>
<thead>
<tr>
<th>Main topic areas</th>
<th>Sub-topics (and major concepts) for grade 7</th>
<th>Sub-topics (and major concepts) for grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>On/off the shorelines</td>
<td>The science of a sunken ship: what happens to things in water</td>
<td>What happens when the earth quakes: what are the causes and effects of earthquakes?</td>
</tr>
<tr>
<td></td>
<td>Changing shorelines: What happens where land and water meet?</td>
<td>What happens when oil spills: what must be considered when determining the impact of an oil spill from an offshore platform?</td>
</tr>
</tbody>
</table>
### Case studies

<table>
<thead>
<tr>
<th>Main topic areas</th>
<th>Sub-topics (and major concepts) for grade 7</th>
<th>Sub-topics (and major concepts) for grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In the cities</strong></td>
<td>Acid rain: how are the world's cities affected by the quality of the air (What is clean air like? Where does acid rain come from? What are the effects of acid rain on city life and structures? How can acid rain be prevented?) How well is the structure designed: what impact do buildings have on the quality of life in the buildings?</td>
<td>Investigating transportation: how do people and goods get from one place to another in the world's cities? Handling information: how is information communicated in the world's cities?</td>
</tr>
<tr>
<td><strong>In the Suburbs</strong></td>
<td>How do structures affect behavior: what is the impact of a structure's habitat on human behavior? How do we keep our water clean: what effects do suburban habitats have on lakes and streams?</td>
<td>Energy for the future: what sources of energy are relied upon for suburban living in the world? Population studies: when the human population increases, what happens to the suburban environment?</td>
</tr>
<tr>
<td><strong>In the marketplace</strong></td>
<td>What's in the food we buy: what additive substances are added to &quot;natural&quot; foods to alter them in the marketplace? Food substitutes: how do artificial foods compare with &quot;natural&quot; foods?</td>
<td>Threads: what materials are used to substitute for natural fibers? Packaging - How does it stack up: what goes into packaging to make it effective?</td>
</tr>
<tr>
<td><strong>In the farmlands</strong></td>
<td>Disappearing farmlands: where does our food come from? How can we get the most from our land: what happens when artificial methods are used to increase yield?</td>
<td>Managing crop pests: how are crop pests controlled to produce the greatest yield, or how are pests controlled in crops? Climate and farming: what effects do climatic changes have on crop yield?</td>
</tr>
<tr>
<td><strong>In ourselves</strong></td>
<td>Examining exercise: how do different types of exercise affect our bodies? Communicable diseases: how is disease spread from one organism to another?</td>
<td>Getting older: what effects does aging have on our bodies? Under the weather: how can weather change affect our health?</td>
</tr>
</tbody>
</table>
Each of the modules contains the student version of the text, a teaching overview, and the background material on the topics to be developed.

One of the important parts of the curriculum is a hands-on laboratory practice, which includes collection and analysis of data, students design and performance of experiments, and presentation of results as a part of investigating possible solutions. At the end of each module, students are expected to prepare a product, e.g. a food produced in accordance with given specifications, blueprints for an innovative school, proposed legislation for pollution abatement in cities, a plan for increasing yield from livestock production, or an exercise video.

Almost all the modules contain at least some environmental concepts. Subtopics such as Acid rain, How do we keep our water clean, How can we get the most from our land, Energy for the future, and Population studies are entirely based on environmental issues.

As an example, the main concepts and activities of the Acid rain teaching unit are summarized below:

**What is acid rain and how does it affect our environment?**

To answer this question, students investigate the scientific concepts of:

- Water cycle
- Solubility
- Solutions
- Acidity
- pH scale
- Dilution

through the following activities:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing a short stylized poem, choosing a picture to illustrate it</td>
<td>Finding out students ideas about air pollution and acid rain</td>
</tr>
<tr>
<td>Collecting information from mass media Performing an instructional game</td>
<td>Establishing/increasing student's awareness on acid rain</td>
</tr>
<tr>
<td>Running dehumidifiers in a classroom for several days, discussing where the water comes from, and performing standard evaporation/condensation/precipitation demonstration</td>
<td>Illustrating the water cycle: how rain is formed</td>
</tr>
</tbody>
</table>
### Case Studies Cont.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tasting lemon juice and water solutions</td>
<td>Taste as a measure of acidity</td>
</tr>
<tr>
<td>Color changing liquids: red cabbage, red radish peels - tests with water,</td>
<td>Natural indicators, acidity, food acids</td>
</tr>
<tr>
<td>lemon juice, vinegar, baking soda</td>
<td></td>
</tr>
<tr>
<td>Testing acid solutions (lemon juice, vinegar, non-food acids) with</td>
<td>Examples of a more precise measurement of acidity; introducing pH scale</td>
</tr>
<tr>
<td>indicator papers and pH meter</td>
<td></td>
</tr>
<tr>
<td>Testing carbonated beverages: the acid formed by carbon dioxide</td>
<td>Illustration of acid formation from carbon dioxide in rain water</td>
</tr>
<tr>
<td>Collecting uncontaminated rain water, measuring pH</td>
<td>Environmental monitoring: pH of the rain in a local area</td>
</tr>
<tr>
<td>Collecting information on acid rain in different locations: student</td>
<td>Searching for the relationship between the distribution of acid rain and</td>
</tr>
<tr>
<td>collected data, encyclopedias, newspapers, journals</td>
<td>the location of pollution sources</td>
</tr>
<tr>
<td>Experiment with calcium carbonate (limestone or marble chips) and acid</td>
<td>Illustrating the damaging effects of acid rain on buildings</td>
</tr>
<tr>
<td>(vinegar, 0.1 M Hydrochloric acid)</td>
<td></td>
</tr>
<tr>
<td>Long-run experiment with metal pins and nails in water and an acid</td>
<td>Illustrating the promotion of metal corrosion by acid rain</td>
</tr>
<tr>
<td>solution</td>
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</tr>
<tr>
<td>Search for lichens in a local area, development of a map</td>
<td>Effect of air pollution to lichens. Spread of acid rain. Effect of traffic,</td>
</tr>
<tr>
<td></td>
<td>coal burning, etc.</td>
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</tbody>
</table>
Case study 3:
An environmental teaching unit in Chemistry

BURNING FUELS: HOW CAN CHEMISTRY HELP US MINIMIZE WASTE MATERIALS AND ENERGY
(Unesco, 1989)

Burning of fuels is the most widely used process for producing heat and generating energy to support human activities. Its theoretical basis includes scientific concepts related to chemistry, physics and biology. The consequences of burning are reflected in several environmental problems.

The unit was prepared by participants of the International Workshop on Energy and Environment as Related to Chemistry Teaching (Unesco, IUPAC/CTC and DOE) at Lawrence Hall of Science, University of California at Berkeley, held in December 1989. Its main structure is summarized below:

The relevant chemistry concepts
- Burning: an oxidation process
- Products of burning and their characteristics
- Energy and matter released in burning
- Burning and entropy increase
- Characteristics of biomass and fossil fuels; advantages and disadvantages in terms of cost, energy content, convenience, waste, environmental impact, alternate uses, etc.
- The environmental impact of specific fuel use: local, regional and global effects
- Scientifically literate decision making about the use of energy and materials

Some chemical solutions
- Elimination of nitrogen oxides and sulfur oxides from exhaust gases and smoke
- Reduction of carbon dioxide and carbon monoxide
- Use of alternative fuels
- More efficient combustion methods
- Reduction of per capita energy consumption

Further in a teaching guide, prerequisite concepts, co-requisite concepts and pedagogical concerns are discussed. Four model teaching unit plans (for 10 to 12 hours) are suggested:

Teaching model A
- Selection of a chemical/fuel related problem that is of local importance
- Problem definition (economic, social, political problems) and searching for solutions (how can chemistry contribute)
- Laboratory experiments: a burning process, testing various fuel sources, efficiency of different fuels - quantitative analysis
- Material outputs: pollutants from different types of fuel
Case studies

- Alternative energy sources
- Local, national and global connections (data bases, maps, graphs)
- Pros and cons of various fuels

Teaching model B

- Demonstration: burning candle
- Collection of newspaper articles related to energy
- Gases produced from burning fuels: laboratory test for sulfur dioxide
- Problems associated with burning fuels: acid rain, greenhouse effect, global warming (sources of carbon dioxide),
- Experiments: energy value of different fuels, complete and incomplete combustion
- Field trip to a power plant of factory
- Spreading of energy and matter (enthalpy and entropy); Activity: rubber band stretching
- Chemistry in fueling automobiles
- Implications of new research on the chemistry of energy and the environment
- Ethical aspects (role playing, discussions)

Teaching model C

- A problem from a newspaper, TV or film
- Class debate: what are the chemical concepts in the identified issue
- Developing skills and procedures to investigate: what knowledge and experiments might be needed to investigate the question
- Research work: theoretical studies, laboratory work, preparing a report
- Reporting and discussing research results
- Searching for other solutions, e.g. alternative energy sources
- Evaluation

Teaching model D

- Need for energy
- Importance of burning
- Selecting a fuel: scientific criteria, practical reasons, undesirable consequences
- Minimizing negative effects on environment: removal of pollutants, more efficient burning, decreased use of fuels, and search for alternative sources

Several classroom activities are listed for the illustration of scientific concepts and for the stimulation of the students participation in data acquisition, problem solving and evaluation:

Laboratory experiments

- Carbon dioxide elimination
- Sulfur dioxide elimination
- Detection and semi-quantitative determination of pollutants
- Removal and masking of pollutants
- Burning causes energy to become more diffuse
- Incomplete versus complete combustion
- Heat of combustion using different fuels
- Effects of gaseous pollutants on plants
- Determination of sulfur dioxide in the combustion products of fuels
- Determination of lead and carbon monoxide in combustion products of fuels
- Infrared detection
- Spectral absorption of materials
- Demonstration of greenhouse effect: carbon dioxide filled model house
Case studies

Field trips: e.g. biomass production, recycling plant, power plant

Library research (data collection)

Analyzing and interpreting data

Taking actions

- Improving personal life at home
- Preparing recommendations for the government
- Establishing recycling, improving insulation of buildings
- Organizing environmental awareness actions.

The teaching guide concludes with an overview on social and technological issues, illustrations of productive and unproductive energy from fuels and with a list of connections to other areas of chemistry, technology, physics, biology, agriculture, social sciences, ethics/religion, health and medicine.
Case study 4:
A cross-disciplinary environmental education teaching unit

SOLID WASTE MANAGEMENT
(Unesco-UNEP program - Hungerford, Volk and Ramsey, 1989)

This teaching unit was prepared for use in a secondary school environmental science program, and is typically organized around four instructional levels recommended by the authors: (1) science foundations, (2) issue awareness, (3) issue investigation, and (4) citizenship action. Its characteristic is a strong interconnection of natural and social sciences. The program does not include any laboratory or field science experiments. Instead, aims at active participation of students in citizenship actions.

Level 1 (science foundation)

1. Problems and issues concerning the production and disposal of solid waste in high and low income countries.
   Activity: an example of different customs and attitudes about solid waste: supper in different countries around the world - typical meal, packaging, household waste.

2. Interesting facts about solid waste (production per capita, figures about junked cars, cans, bottles, plastic, paper: data on recycling; present situation and future of landfills).

3. Definition of solid waste (municipal, agricultural, industrial, mining).

4. Hazardous households wastes (ignitable, corrosive, reactive or toxic).
   Activity: Reviewing the list of hazardous household products and recognizing them at home.

5. Solid waste generation: comparison of refuse generation data from different parts of the world.
   Activity: calculating average amount of refuse for high-income and low-income cities.

6. Why so much garbage in our country (USA)? Analyzing different sources and products.
   Activity: examining and discussing packaging of different food products (what are the functions of different packaging, what is essential for the quality, what is wasteful; what is recyclable, renewable, what is biodegradable).

7. What happens to solid waste?
   a) Littering and open dams.
   b) Sanitary landfills.
   Activity: What happens to our garbage? Tracing the garbage from home to the final disposal. Possibilities for data collection: (1) field trip to waste collection service and local landfill, (2) guest speaker from local solid waste disposal).
c) Solid waste incineration.
d) Resource recovery: recycling (environmental benefits of using recycled resources, recovery rates for different materials around the world).
Activity: Classification of solid waste items (organic, renewable/recyclable, nonrenewable/recyclable, nonrenewable/hard to recycle) and discussing the appropriate disposal forms for them (reuse, recycle, recover energy, landfill).

Level II (issue awareness)

1. An example of solid waste management issues (a story)
2. Beliefs and values. Defining terms: problem, issue, player, position. Description of values (aesthetic, cultural, ecological, economic, educational, egocentric, ethical/moral, health, legal, political, recreational, religious, scientific, social).
   Activity: identifying the values in the examples of different statements.
3. Identifying solid waste management problems and issues in secondary source literature.
   Activities: (a) reading of selected articles, identifying problems and issues, beliefs and values (b) writing bibliographic citations.
4. Developing an issue web on solid waste management issues.

Level III (issue investigation)

1. An overview of the issue investigation process (review the status of a solid waste issue, generate research questions, develop a data collection strategy, collect data, interpret data).
2. Identification of issues investigation topic (identify categories and variables appropriate for issue investigation).
3. Guidelines for research questions (examples of questions, design of questionnaires, letters, etc.)
4. Data collection: organizations associated with the problems and issues of solid waste management.
5. Data interpretation: conclusions and recommendations.

Level IV: Citizenship action

1. Modes of action: analyzing the available strategies (persuasion, activism, consumerism, political action, ecomanagement).
2. Selecting and evaluating actions: preparing an action analysis criteria worksheet.
3. Preparing the solution analysis worksheet: identifying consequences of the proposed solution, benefits and losses.
4. Preparing the action plan, final evaluation.
5. Implementation of the action plan.*

*Implementation of environmental actions is a constructive step in developing students' skills for the active participation in solving environmental problems. However, this approach may also have a negative side effect. Secondary students might feel that the very basic knowledge they have on environmental issues is sufficient and entitles them to take any environmental action. Because of the lack of profound scientific knowledge and insufficient acquaintance with the complexity of environmental issues, many "amateur" environmental actions have failed or even had more negative than positive effects on people and on the environment itself.
Case study 5: A science/environment teaching unit based on observation, experiments and construction activities

THE SOLAR ENERGY
(Deleage and Souchon, 1986; adapted from work by a group of teachers at the Active Methods Training Center, College J. Valeri, Nice)

In contrast to the previous case study, the subjects in solar energy teaching unit remain within natural science and technology. Students' interests and activities are mainly focused around one scientific phenomenon: the transformation of solar radiation into heat. Study of this theme, together with efforts to reduce energy losses and construct efficient devices for practical use, grows into different fields of science and technology (astronomy, physics, chemistry, engineering, architecture). The program is action oriented and aims primarily at energy conservation and transition to renewable energy sources.

Study of the sun

- Solar phenomena: sun spots, granulation, limb darkening
- Solar radiation: solar spectrum, solar constant
- Motion of the sun and planets

Study the above phenomena and use (or construct) simple instruments: gnomon, sundial, heliometer, heliostat, theodolite, sun compass, helioscope, etc.

Solar energy

Collecting the solar energy (solar collectors): study (and try to explain) the following phenomena:
- Influence of color
- The greenhouse effect (single, double, triple glazing; comparison of glazing materials; distance between two glazing layers; distance between glass and absorber)
- The concentration effect (position-seeking mirrors: semi-cylinder, cone, paraboloid, sphere; position of absorber with respect to reflector)
- Importance of insulation: test of various materials
- Comparative study of the thermal properties of materials
- Importance of the direction of the collector
- Importance of evaporation in a heat exchanger and in a swimming pool
- Photo-voltaic cells

Heat exchange and storage
- By contact
- By circulation of a liquid or gas

Problem of sitting houses: roofs are designed to avoid the sun reaching the south-facing wall in the Southern hemisphere.
Study and design

- A model house operating on solar energy
- Reduce the heating of air in tents

Design, construct and use the practical devices based on solar energy

- Experimental solar collector
- Hot-air collector for use in a classroom
- Solar lighter
- Solar grill
- Solar shower
- Solar energy hot-air balloon

Search for solutions to environmental problems

- Try to reduce the excessive heating of buildings due to sun radiation
- Search for different possibilities of replacing traditional sources of energy with solar energy
Case study 6:

EXAMPLES OF ENVIRONMENTAL EXPERIMENTS AND OTHER ACTIVITIES

Environmental activities in the local environments

Atrea, Lahiry, Gill, et al. (1985), have prepared a unit based on experiments and activities to facilitate the teaching of environmental themes in primary schools. It is designed primarily to use available opportunities around the school, thereby linking fundamental science and environmental knowledge to the daily life experiences of the students. Most of the listed practical activities can easily be adapted for secondary school environmental programs, for example:

Table 11: Examples of simple environmental experiments and activities using available resources around the school as a part of science teaching

Legend: AGRI = agriculture, ARTS = art subjects, BIOL = biology, CHEM = chemistry, HEALTH = health education, HOEC = home economics, NASC = natural science, PHYS = physics, SOSC = social science

<table>
<thead>
<tr>
<th>Local resource</th>
<th>Examples of simple environmental activities</th>
<th>Link to subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANIMALS: domesticated, wildlife</td>
<td>Observe the local animal life. Note the type of food animals eat. Look for possible food chains (who eats whom).</td>
<td>BIOL</td>
</tr>
<tr>
<td></td>
<td>Talk to farmers about the care and feeding of animals. Discuss possible fodder and animal waste problems.</td>
<td>BIOL, AGRI</td>
</tr>
<tr>
<td>PLANTS</td>
<td>Air pollution: Collect plant leaves from different areas. Cut identical surface area from each sample and wash it with distilled water. Evaporate the water, analyze and compare the residues</td>
<td>BIOL, CHEM</td>
</tr>
<tr>
<td>NATURAL ENVIRONMENTS</td>
<td>Life on a tree. Observe closely the organisms living on a big tree (on the trunk, under the bark, on the branches, among the leaves, etc.) What are these organisms? What are their interactions? Which biological, chemical and physical process are important for what you see.</td>
<td>BIOL, CHEM, PHYS</td>
</tr>
<tr>
<td>GARDEN at school or at home</td>
<td>Try to make your own compost (study how to make it, what are the biological and chemical processes). Use it as a natural fertilizer in the garden.</td>
<td>BIOL, CHEM, AGRI, HOEC</td>
</tr>
</tbody>
</table>

*Modifications and suggestions have been made by the author of this report.
### Local resource

#### Examples of simple environmental activities

<table>
<thead>
<tr>
<th>Local resource</th>
<th>Examples of simple environmental activities</th>
<th>Link to subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDINGS</td>
<td>Examine the types of buildings in the locality. Identify the materials used for construction and think about their source, use, purpose, and environmental impacts. Study the systems of water supply and drainage.</td>
<td>CHEM, PHYS, HEALTH</td>
</tr>
<tr>
<td></td>
<td>Think about the insulation, heating and cooling systems, and possible energy conservation.</td>
<td>PHYS, CHEM</td>
</tr>
<tr>
<td>SHOPS</td>
<td>Observe how products are packaged and how they are delivered to the customer to take away. What is the purpose of different packaging materials and forms? What is essential and what could be omitted? What could be improved? Which materials for packaging are renewable and which are not? Which are biodegradable? What happens to them at home? What happens to them when they are discharged?</td>
<td>CHEM</td>
</tr>
<tr>
<td>FOOD PLACES</td>
<td>Observe the way the food items are prepared, stored and served, and comment on the environmental sanitation.</td>
<td>HEALTH</td>
</tr>
<tr>
<td></td>
<td>Analyze different types of serving: paper plates, plastic, glass, porcelain, metal, plastic or paper bag, paper napkin, plant leave, etc., from the viewpoint of hygiene, sanitation, aesthetics, raw materials, energy consumed, waste treatment.</td>
<td>CHEM, HEALTH, PHYS, ARTS</td>
</tr>
<tr>
<td>HOME (your own home, neighbors)</td>
<td>Observe the characteristics of a family: family size, earning, living space, percentage of income spend on food and fuel; food habits, water supply, garbage disposal procedure, etc., and comment the above information from the environmental viewpoint; suggest possible improvements.</td>
<td>SOSC, NASC., HEALTH</td>
</tr>
<tr>
<td></td>
<td>Study different fuel types and their usage in your home and neighborhood. Look at quality and prices, quantities used, environmental impacts and propose improvements.</td>
<td>CHEM PHYS</td>
</tr>
<tr>
<td></td>
<td>Try to find the common hazardous household products in your home. Study their chemical composition (from the labels), relate it to their purpose, and think of their effect on the environment (1) during their production, (2) during their use, (3) when discharged.</td>
<td>CHEM, HOEC</td>
</tr>
<tr>
<td></td>
<td>Examine the food habits of yourself and your family. What are the main reasons for food wastage? Think of the chemical composition of food. Try to calculate the caloric value and how much carbohydrates, proteins, fats, vitamins and salt you approximately consume per week. Study the food requirements. Think about the possible improvement of your diet and try to change it, if it is not adequate.</td>
<td>CHEM, BIOL, HEALTH, HOEC</td>
</tr>
</tbody>
</table>

Legend: AGRI = agriculture, ARTS = art subjects, BIOL = biology, CHEM = chemistry, HEALTH = health education, HOEC = home economics, NASC = natural science, PHYS = physics, SOSC = social science
Case studies

Measuring and analyzing (practical work in ecology)

The following short overview of simple ecology field study techniques offers suggestions for measuring abiotic factors on land and in water, and for collecting and sampling animals and plants in ecosystem studies. The necessary equipment or analytical method is listed for each parameter. Examples of relating environmental concepts are suggested, which may be explained or illustrated by practical field work (Table 12).

Table 12: Examples of simple ecology field study techniques (main source: Slingsby and Cook, 1986)

<table>
<thead>
<tr>
<th>ABIOTIC PARAMETERS ON LAND</th>
<th>EQUIPMENT or ANALYTICAL METHOD</th>
<th>RELATING ENVIRONMENTAL CONCEPTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity</td>
<td>Light meter</td>
<td>Light intensity is one of the abiotic factors determining the dominating plant species and variations in ground flora.</td>
</tr>
<tr>
<td>Light compensation point</td>
<td>Specimen tube, rubber bung, bicarbonate indicator</td>
<td>Light intensity at which rate of carbon dioxide from respiration equals consumption of carbon dioxide in photosynthesis.</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Anemometer or wind meter</td>
<td>Desiccating effect, xeromorphic adaptations of plants. Erosion. Wind carrying sand and salt. Mechanical damages, effect of plant shape and species variety.</td>
</tr>
<tr>
<td>Humidity</td>
<td>Hygrometer or atmometer</td>
<td>Humidity and evaporation rate. Xeromorphism.</td>
</tr>
<tr>
<td>Air temperature</td>
<td>Thermometer</td>
<td>Air temperature affects transpiration and cell metabolism. When cytoplasm freezes, the cell is damaged. Temperature affects the length of growing season.</td>
</tr>
<tr>
<td>Soil temperature</td>
<td>Soil thermometer</td>
<td>Soil temperature fluctuates less than air temperature. Soil temperature is related to soil type and water content. Sun exposed slopes are warmer.</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>Laboratory (or domestic) oven, laboratory balance</td>
<td>Rainfalls, drainage, soil water holding capacity. Plant adaptations.</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>Muffle furnace or Bunsen or camping burner, or a stove</td>
<td>Humus - a reservoir of plant nutrients. Layered structure of soil. Soil horizons.</td>
</tr>
<tr>
<td>Slope</td>
<td>Manometric level or ranging pole</td>
<td>Drainage, washing out of plant nutrients. Soil erosion. Difficult seedling establishment.</td>
</tr>
<tr>
<td>Soil pH</td>
<td>pH indicator or pH meter</td>
<td>Acid, neutral and alkaline soils. Solubility of minerals. Plant adaptations.</td>
</tr>
<tr>
<td>ABIOTIC PARAMETERS IN WATER</td>
<td>EQUIPMENT or ANALYTICAL METHOD</td>
<td>RELATING ENVIRONMENTAL CONCEPTS</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Water pH</td>
<td>pH indicator or pH meter</td>
<td>Effect of geological structure and carbon dioxide level. pH range specific water organisms.</td>
</tr>
<tr>
<td>Turbidity, total and suspended solids</td>
<td>Long glass tube (1 m) or a Secchi disc; Filter funnel, balance; Water bath, oven</td>
<td>Organic pollution - reduced light penetration - reduced primary production (plant photosynthesis) - reduced oxygen level - effects on animals.</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>Conductivity meter (in addition, special indicators or standard analytical procedures may be used for the determination of ions)</td>
<td>Ionisable substances in water (phosphates, nitrates, nitrites) - natural or as a result of pollution (fertilizers, waste waters, salinization). Eutrophication. Algal blooms.</td>
</tr>
<tr>
<td>Flow rate</td>
<td>Commercial flow meters, or a Rubberbag mater, or a Pooh stick, measuring tape and a stopwatch</td>
<td>Aeration. Adaptations of organisms to high flow rate. Erosion and siltation.</td>
</tr>
</tbody>
</table>
### ORGANISMS | SAMPLING METHOD | RELATING ENVIRONMENTAL CONCEPTS
--- | --- | ---
Plants and sedentary animals | Quadrat frames (wire quadrats, wooden quadrats) | Species frequency
| | | Species density
Earthworms | Repulsion method utilizing quadrat frames and 30 percent methanol | Species cover
| | | Species diversity
Soil arthropods | A sieve, lamp, funnel, collecting vessel with 30% methanol | Estimation of population size
| | | Heterogeneity (zonation, gradients, mosaics)
Soil nematodes | A gauze bag, funnel, collecting vessel | Studying ecological relationships
Litter invertebrates | Quadrat, sieve, Pitfall traps: container with a roof (can, jar) | Estimation of pollution (indicator species of clean and polluted environments)
Airborne invertebrates | Nets
| Sticky traps
| Water traps
| Light traps | 
Small mammals | A Longworth mammal trap, a trip-trap | 
Aquatic animals | Plankton nets
| Nekton nets | 
Sediment animals | Framed net and a quadrat | 

For chemistry-related experiments in environmental education see the sections on experimental work in Case Studies 1 (ChemCom), 2 (FACETS) and 3 (Burning fuels).
Case study 7:

ENVIRONMENTAL RESEARCH PROJECTS IN SECONDARY SCHOOLS

Examples from Slovenia

Slovenia has a long tradition of international or national summer science schools and research/education camps for teachers or student/teacher groups, as well for youth research projects supervised by teachers. For example, the following secondary school youth research projects with environmental approach were presented at the 26th Meeting of young researchers and innovators of Slovenia in June 1992 (Boh and Kornhauser, 1992):

WORKING GROUPS:

Biology

Investigation of the state of environment in the area of the river Koritnica
Toxicology test on fish
Protection of the river Krka with special emphasis on the investigation of Brsijanski potok
Presence of radioactive elements in lichen
Toxicity tests on fresh water algae Ankistrodesmus falcatus
Air pollution in Ptuj
Creek pollution in Breterniska grapa
Ecological problems of Slovene thermal power stations and possible solutions
Toxicity tests on algae Scenedesmus quadricauda

Ecology

Impacts of polluted environment on human life and health
Introduction of ion exchangers in water analysis
Extraction of zinc and sludge recycling
Ecologically acceptable products from Maribor industrial companies

Physics

Measures against traffic noise

Geography

Application of synthetic fertilizers and additives from a geographical point of view to environmental protection
Impacts of polluted environment
Waste dumps
Chemistry

Toxicological study of food additives
Water quality at Nevišica
Zinc removal from water solution
Study of industrial waste waters from plating processes: waste waters investigation for nickel and chromium
Comparison of air pollution standards
Pollutants in school laboratory - qualitative and quantitative determination, possibilities of their recovery
Lead content in human and animal skin
Air cleaning using biofilters
Measurements of radioactive emissions in the vicinity of radioactive waste disposal site in Zavratec
Phenol determination in waste waters
Efficiency of oily waste water treatment using ultrafiltration
Efficiency of waste water treatment plants for sustaining river quality
Replacement of drinking water in industrial applications with treated river water
Determination of physical and chemical conditions for treatment of Revoz waste water
Experiments to select a treatment type of urban polluted water

Mechanical engineering

Ecologically acceptable pre-transport of ashes (or powder materials)

An example from Sweden

In 1980's selected secondary schools participated in an experimental environmental education program for the natural science. For three years, students spend 8 to 9 periods per week on project-oriented environmental protection program. This methodology was adapted from similar projects in chemistry.

The main project themes are given below (Egneus and Tullberg, 1985):

<table>
<thead>
<tr>
<th>Water projects</th>
<th>Land projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Investigation of lakes</td>
<td>- Acidification</td>
</tr>
<tr>
<td>- Investigation of fjords</td>
<td>- Agriculture and environment</td>
</tr>
<tr>
<td>- Water supply</td>
<td>- Energy forests</td>
</tr>
<tr>
<td>- Mussel production</td>
<td>- Alternative plant production</td>
</tr>
<tr>
<td></td>
<td>- Local hardwood forests</td>
</tr>
<tr>
<td></td>
<td>- The dying forest</td>
</tr>
<tr>
<td></td>
<td>- Photo exhibition on environmental protection</td>
</tr>
</tbody>
</table>
Examples of interdisciplinary environmental projects from Norway (Kvam, 1985)

Model 1: Pollution

Students, in cooperation with science teacher, suggested the project themes and methodology. No special content limits were given within the available time frame of two months with five hours per week. At the end students submitted the final report.

Topic 1: Air pollution

1. Information studies:
   - textbooks, newspapers, magazines, radio, TV.
2. Experiments:
   - Demonstration experiments at the university:
     - Burning of oil results in acid rain
   - Student practice:
     - Burning of sulfur gives sulfur dioxide, gas and acid water
     - The consequences of acid water (containing sulfuric acid) on minerals, limestone, metals; bacteria and animals living in the earth; growth of plants, crustacean, mussels and other fish foods; fish larvae, young and adult fish.
3. Field work and report studies:
   - Analysis of snow from different parts
   - A study of lichens
4. Excursions: measuring station of air pollution; institute for air research; local electric power station.
5. Interviews: parents, old people, people in the street, specialists at electric power station, county environmental office, local labor commission, nature preservation association.
6. Preparation and presentation of reports: individual and in groups. illustrations, posters, newspaper articles, lectures for other classes.

Topic 2: The sea as an ecological system

Sub-themes:
- The sea as an ecological system
- Resources, plants and animals
- Resources, oil and gas
- Aquacultures
- Threats to marine life

Activities:
1. Literature studies: books, reports, magazines, newspapers
2. Field work: study of the sea ecosystem and aquacultural constructions
3. Lectures: oil extraction, aquacultures
4. Exhibitions: oil extraction in Norway
5. Interviews: researchers, fishermen, industrial specialists, oil companies, nature preservationists.
Model 2: Human sexuality and propagation

The contents and the methodological approaches were suggested, designed and taught by teachers of different subjects. In the individual subject sessions a teacher and students were entirely free to choose what they would work with. Interest and personal engagement seemed to be important for a good teaching-learning situation.

Biology:
sexual organs, hormones, contraception, intercourse, masturbation, abortion, venereal diseases, sexual deviation.

Gymnastics:
physical development and sexual hormones, menstruation cycle and physical education, sexual hormones as doping drugs.

Mathematics:
statistics, data as a source of information, analysis of sexual debut age, divorce frequency and venereal diseases.

Mother tongue (Norwegian):
concepts such as: love, infatuation, sexual press, sexual role, fiction as a source of knowledge about problems connected with living together; analysis of how the different literary forms present these problems; discussion and possibly written work.

Civics:
the world population problems and family planning; attitudes towards the use of contraceptives in different cultural and social systems, and practical problems in this respect.
Examples of other action-oriented environmental education programs and activities

Table 13: Examples of action-oriented environmental education programs and activities from different countries

<table>
<thead>
<tr>
<th>Program/Project</th>
<th>Characteristics</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cooking Food Energy Cycle (rural secondary school)</td>
<td>How to reduce the amount of energy for cooking (improving the efficiency of commonly used three-stone stove &quot;maphifwa&quot;, selecting better firewood types)</td>
<td>Gumbonzvanda, Zimbabwe</td>
<td>Knamüller, 1987</td>
</tr>
<tr>
<td>KENGO - Kenya Energy and Environment Organizations (community development and environmental conservation program in cooperation with schools and polytechnics)</td>
<td>Introduction of tree nurseries to several local schools. Improvement of traditional stoves to cut the fuelwood budget by up to 50%.</td>
<td>Kenya</td>
<td>Munene, 1992</td>
</tr>
<tr>
<td>Welo's environmental education program (a soil conservation and community forestry program, including teacher training and practical work for students)</td>
<td>Secondary school students spend 2 - 6 hours per week on practical work: construction of terraces, check-dams, tree planting, establishment of vegetable gardens, irrigation techniques, agro-forestry.</td>
<td>Ethiopia</td>
<td>Fitzgerald, 1990</td>
</tr>
<tr>
<td>The Science in Ghanaian Industry-oriented interdisciplinary Ghana project (trial testing in secondary schools)</td>
<td>Industry-oriented interdisciplinary science teaching based on concepts and processes identified in indigenous industries (booklets written by local industries, students workbooks, teacher's guide)</td>
<td>Ghana</td>
<td>Yakubu, 1989</td>
</tr>
<tr>
<td>Program/Project</td>
<td>Characteristics</td>
<td>Location</td>
<td>Reference</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
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</tr>
<tr>
<td>ESNACIFOR - Honduras National School of Forestry Science</td>
<td>Environmental education programs on planting and conserving trees for students, children, farmers and forest dwellers</td>
<td>Honduras</td>
<td>Gall, 1990</td>
</tr>
<tr>
<td>Secondary school ecology studies and projects (ecology clubs)</td>
<td>Project work, e.g. ecology of a local river, animal and plant life in the city park; pollution measurements in the cities; effects of heavy metals on red blood cells.</td>
<td>Bulgaria</td>
<td>Kostova, 1989</td>
</tr>
<tr>
<td>WAP - the Water Analysis Project (cooperation of five secondary schools: 2 technical, 1 art, 1 pedagogical, 1 vocational)</td>
<td>Analysis of surface and ground waters: within the framework of normal instruction. Students conduct the complete water analysis from different sites and submit the reports to local authorities</td>
<td>Mantova, Italy</td>
<td>Sutti, 1991</td>
</tr>
<tr>
<td>The Acid Rain Project (students and teachers of middle and high schools)</td>
<td>The project (1988) covered the whole national territory - schools were involved in collecting data from 900 sampling points. A special kit was developed and distributed for this purpose. Results were summarized in a map of acid rain spread in Italy.</td>
<td>Italy</td>
<td>Bargellini, 1989</td>
</tr>
<tr>
<td>Laboratory Waste Treatment (university level)</td>
<td>Waste waters from the laboratories in the universities are treated at treatment facilities of university campuses as a part of regular environmental training and pollution prevention programs.</td>
<td>Japan</td>
<td>Tamaura and Abe, 1989</td>
</tr>
<tr>
<td>Education for Recycling Energy from Waste (university level)</td>
<td>A waste management information system (generation, characteristics, processing and disposal of waste) was built by combining research, educational and industrial information. It provides support to research and development projects, governmental decision making and teaching.</td>
<td>Slovenia</td>
<td>Kornhauser et al., 1989</td>
</tr>
<tr>
<td>Program/Project</td>
<td>Characteristics</td>
<td>Location</td>
<td>Reference</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>----------------</td>
<td>-----------</td>
</tr>
<tr>
<td>(secondary school syllabus introduced in 1985)</td>
<td>sources, firewood and charcoal, oil spills, greenhouse effect</td>
<td>(Caribbean islands)</td>
<td></td>
</tr>
<tr>
<td>Elements of Chemistry: Earth, Air, Fire and Water (final two years of secondary</td>
<td>Chemistry as a multi-dimensional subject with social, economic, human, environmental, technological and industrial dimensions, relating to every day experiences.</td>
<td>Australia</td>
<td>Bucat, 1989</td>
</tr>
<tr>
<td>school)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry, Technology and Society (an undergraduate course)</td>
<td>Energy and the environment in Brazil - subject modules: statistical data, processes, raw materials, waste treatment</td>
<td>University of Sao Paulo, Brazil</td>
<td>Isuyama, 1989</td>
</tr>
<tr>
<td>Environmental management (an optional high school subject)</td>
<td>Project-oriented environmental education based on field work (e.g. studies of local ecosystems, natural parks, industrial pollution, soil contamination, acid rain)</td>
<td>Sweden</td>
<td>Mellgren, 1988</td>
</tr>
<tr>
<td>Environmental education for development (secondary schools)</td>
<td>Environmental education project work on the river Tagus - with several participating schools along the river</td>
<td>Portugal</td>
<td>Nogueria, 1988</td>
</tr>
<tr>
<td>Reflections on a Breakthrough (secondary school students)</td>
<td>Phosphate-containing detergents: conducting market research study, providing information on phosphate negative environmental effects, changing buying habits of local population</td>
<td>Norway</td>
<td>Folkedhal, 1991</td>
</tr>
</tbody>
</table>
Cont.

<table>
<thead>
<tr>
<th>Program/Project</th>
<th>Characteristics</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary School Environmental Initiative</td>
<td>Influencing the local population: introduction of environmentally-sound shopping bags; effecting direct changes in the environment: laying out a biotope in a private garden; informing the local population: leaflets and newsletters</td>
<td>Austria</td>
<td>Haas, 1991</td>
</tr>
<tr>
<td>Waste Project</td>
<td>Emancipation through environmental projects</td>
<td>Oberwart District, Austria</td>
<td>Schweitzer, 1991</td>
</tr>
<tr>
<td>History and Environment</td>
<td>Teaching environmental protection through history</td>
<td>Hungary</td>
<td>Horvath, 1987</td>
</tr>
<tr>
<td>Interdisciplinary teaching of mathematics, physics, chemistry, and social science (9th grade students)</td>
<td>Consumer studies, energy issues, chemistry in the service of mankind, alcohol and narcotics,</td>
<td>Denmark</td>
<td>Norskov and Overgard, 1985</td>
</tr>
</tbody>
</table>
Case study 8:
A comprehensive environmental teaching manual for secondary school teachers

SOURCEBOOK IN ENVIRONMENTAL EDUCATION
FOR SECONDARY SCHOOL TEACHERS
Sharma and Tan (Eds.), 1990

The Sourcebook on Environmental Education is the result of a regional training course which was organized by Unesco at the University of Philippines in 1989. Its main target groups are pre-service and in-service secondary school science teachers, but it is an equally valuable source of environmental knowledge (Part I) and pedagogical aspects (Part II) for all other teachers and trainers, curriculum developers and education policy makers. The sourcebook is a good example of a joint work. Different chapters were prepared by recognized Asian specialists from different environmentally related fields. The structure of a sourcebook is given in table 14.

Table 14: Structure of an environmental teaching manual for secondary school teachers, prepared by recognized Asian specialists from different environmentally related disciplines (Sharma and Tan, Eds., 1990)

<table>
<thead>
<tr>
<th>Chapters:</th>
<th>Contents:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART I: THE KNOWLEDGE BASE</td>
<td></td>
</tr>
<tr>
<td>1 R.B. Aspiras</td>
<td>The concept of environmental education:</td>
</tr>
<tr>
<td></td>
<td>Definition</td>
</tr>
<tr>
<td></td>
<td>Philosophy and aims</td>
</tr>
<tr>
<td></td>
<td>Environmental crises as products of the adoption of western systems:</td>
</tr>
<tr>
<td></td>
<td>- Hazardous products and technologies</td>
</tr>
<tr>
<td></td>
<td>- The green revolution</td>
</tr>
<tr>
<td></td>
<td>- Destructive fishing techniques</td>
</tr>
<tr>
<td></td>
<td>- Destruction of mangrove forests</td>
</tr>
<tr>
<td></td>
<td>- Energy mega projects</td>
</tr>
<tr>
<td></td>
<td>Towards establishment of the curriculum</td>
</tr>
<tr>
<td>2 R.A. Tabbada</td>
<td>Structure and function of the ecosystem</td>
</tr>
<tr>
<td></td>
<td>What is ecology</td>
</tr>
<tr>
<td></td>
<td>The ecosystem</td>
</tr>
<tr>
<td></td>
<td>Ecosystem components: biotic and abiotic factors</td>
</tr>
<tr>
<td></td>
<td>Ecosystem structure</td>
</tr>
<tr>
<td></td>
<td>Ecosystem function</td>
</tr>
<tr>
<td>Chapters:</td>
<td>Contents:</td>
</tr>
<tr>
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- Attitude test

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**Sample instruments for evaluating training programs**
- Evaluating training outcomes
- Evaluating training program
- Evaluating peer teaching demonstration

### Appendix 4

**Worksheets for organizing field investigations**

- **Ecosystem structure and function:**
  - Quadrat record sheet: floristic method and physiognomic method
- **Energy flow and nutrient cycles in the biosphere:**
  - Standing crop table
  - Table of net primary production
- **Environmental impact assessment**
- **Water ecosystem**
- **Energy and mineral resources degradation**
- **Community based environmental education:**
  - Sample 1: Minimizing noise pollution
  - Sample 2: Save electricity
  - Sample 3: Green is clean and beautiful
  - Sample 4: Population growth
  - Sample 5: Natural resources
  - Sample 6: Water pollution
Case study 9:
An interdisciplinary environmental education unit for secondary science teachers

ENERGY: AN INTERDISCIPLINARY THEME
(Dealege and Souchon, 1986)

The interdisciplinary unit on energy was designed primarily for training of secondary school science teachers, and therefore provides (1) the basic scientific knowledge necessary for understanding issues on energy and environment; (2) possible methodological approaches and activities; (3) a detailed eight-unit teaching module, comprising teacher's presentation texts, list of instructional materials needed for each unit, instructions for student activities, experiments and projects, and suggestions for possible infusion of specific energy topics into different school subjects.

BASIC CONCEPTS

Energy in the universe and in human society
  Energy in the cosmos
  Energy in the biosphere: Ecosystems
    Flow of energy and energy chains
    Energy efficiency in ecosystems
  Evolution of societies and energy use
  Links between energy and types of civilization

Energy sources and resources
  The concepts of energy sources and resources
  Various types of energy sources and resources
    Renewable: the sun, hydraulic, wind, wave, tidal, biomass, geothermal energy
    Non-renewable: coal, oil, gas, nuclear fuel
  Use and management of energy resources - case studies in eco-energy analysis
    Crops
    Farming
    Agricultural systems in various countries
    Cities and ecosystems (example of energy flow in Paris)
    Production methods

Energy and development
  Energy production and consumption per capita
  Energy use in agriculture and industry

Energy and environment
  Environmental effects of human activities involving use of energy
THE EDUCATIONAL METHODS AND THEIR APPLICATIONS

Educational approaches
(guided environmental interpretation, discussion groups, value analysis, games and simulations, experimental workshops, action-directed solution of problems, the educational follow up)

Various types of activities: applications to the energy theme
Analysis of literature
(e.g. economic statistics, texts)
Analysis of concrete environmental situations
(e.g. share of individuals in energy consumption; analysis of energy consumption related to housing in different climatic conditions; drawing-up energy balances by eco-energy analysis)
Manual activities and experiments
(e.g. construction of a flat-plane solar collector for heating water; the scientific principles involved: the greenhouse effect, the heat-absorbing properties of a given surface, the transport of heat by air or water, storage of heat using various materials)
Search for solutions to environmental problems
(e.g. energy savings, recycling operations, alternative sources of energy)

ENERGY TEACHING MODULE

The module consists of 8 sections:
Energy-definitions and forms
Unites of energy and power: the concept of efficiency
The history of the use of energy
Energy chains and the transport of energy
Energy sources and resources
The production of energy
The consumption of energy (home, industry, agriculture, construction, transportation)
Energy economics and energy savings

For each section the following is provided:
Well structured presentation text for a teacher with outlined basic scientific concepts
School subjects for possible infusion of this theme
List of materials needed for teaching
Instructions for preparing worksheets
Examples of possible exercises and projects for students

APPENDICES

Additional basic concepts
(energy definitions and characteristics, principles of thermodynamics, mass and energy)
Statistical and other data on energy
Glossary of terms
Case study 10:

EXEMPLARY OF ENVIRONMENTAL KITS AND PACKS

The Mobil Greensight Pack (Living Earth, 1992)

The pack is a new type of environmental education resource, providing practical guidance to enable a team of students to produce a quality video or other audiovisual documentary about a local industry's impact on the environment. The basic instructional materials are further illustrated with five case studies. Its possible applications and uses include environmental components of science, geography, media studies, foundation studies and cross-curricular themes.

The pack is a team product of Living Earth environmental educationalists and The Green Alliance environmental policy specialists, and sponsored by Mobil. It contains one hour video, a manual with skills cards and activity sheets, expert research briefs on environmental issues and a planner wall chart.

Rainforests Resource Pack (Living Earth, 1992)

The pack was prepared by teachers, environmentalists and designers, and is planned for active learning and resource-based learning in both primary and secondary schools. Each pack consists of:

- four large color broadsheets: (1) The living forest, (2) The Human Forest, (3) The Falling Forest), (4) The Future Forest. (The sheets, which are an easy-to-follow visual trail through the issues surrounding the survival of rainforests, won graphic design awards in UK and USA);
- four detailed sets of teacher's notes (background information data, examples, case studies);
- two sets of briefing documents on teaching styles and approaches to environmental education;
- a set of action cards for pupils, with guidelines to set up a local rainforests support group,
- two copies of a handbook on tropical rainforests,
- a comprehensive reading and resource list.

Math and the Tropical Rainforests (Collins, 1992)

The resource pack put mathematics into a context of tropical forests. Students can explore the issues of rainforests through a wide variety of mathematical problems, investigations and data-handling exercises. Teacher's notes are included as well. Topics include:

Set 1: Area measurements
    - Mathematical modeling
    - Graph techniques
    - Probability
    - Four rules of fractions

Set 2: Surveys
    - Spreadsheet exercises
    - Percentages
    - Interpreting graphs
    - Estimation methods.
Environment and development kit (Visuel Inform A.S., Norway, 1992)

The kit is designed for secondary school, college and adult environmental education and covers the topics of oceans, desertification, soil erosion, rainforests, greenhouse effect, ozone layer depletion, the debt problem and arms race. It contains 38 color overhead transparencies with side panels providing additional information, and a resource guide with lesson plans for each of the above topics (Connect, 1992).
ENVIRONMENTAL EDUCATION AND THE WORLD BANK

The Bank and the environment

Two decades ago, the main environmental concerns were traditional scientific ecology and pollution control in industrial countries. Since then, the meaning of the term environment has extended to diverse issues such as global pollution, soil fertility deterioration, tropical deforestation, biodiversity and protection of wildlife, protection of tribal peoples and cultural heritage, natural resources management, introduction of clean technologies and environmentally sound agricultural practices. These concerns became evident in the policies and lending operations of the World Bank.

The World Bank recruited its first environmental consultant in 1969. Shortly after, the Office of Environmental Affairs was established. This has had some impact on Bank projects, but the importance and complexity of environmental issues were not fully realized until the 1980s after a public debate about the environmental impact of Bank loans to finance some large projects in developing countries (Botswana Livestock project, Polonoroeste project in Brazil, and the Indonesia Transmigration project). The adjustment of Bank’s policies in 1987 to address environmental management issues was partly a result of public criticism, and partly a consequence of a growing evidence of the close connection of economic development and environmental protection. The concept of "depreciation of natural capital", which puts a price on environmental degradation, was then introduced into the Bank policy and evaluation of projects (Thulstrup, 1989; Warfond and Partow, 1989).

Since then, the Bank environmental policy has been implemented through a series of activities, such as:

(1) environmental studies for borrower countries, identifying key environmental problems and their causes,
(2) environmental overall country action plans undertaken by governments with local, national and international participation,
(3) in-depth environmental studies of selected environmental problems in a country, e.g. deforestation in Brazil, and
(4) regional environmental studies, such as the Environmental Program for the Mediterranean, Capital Cities Clean-up Project for the Asian Region, and a study of the role of geographic information in renewable resource management in Sub-Saharan Africa (Warfond and Partow, 1989).

An analysis of the World Bank loans in the fiscal year 1989 (Figure 4) shows a strong concern for environmental protection in agriculture and rural development projects, followed by energy, transportation, water and sewerage, industry and urbanization. Educational programs seem to pay relatively little attention to environmental issues.
The Bank and education

The World Bank is not only the single largest source of external funding for education, but it is also an important source of analytical and policy work in educational issues. The 1992 World Bank Annual Operational Review on Education and Training (PHREE, 1992) shows the diversity in nature and scope of lending for education. In fiscal year 1992 Bank provided loans and credits for pre-primary, primary, secondary and higher education, as well as for employment, science and technology, non-formal education and adjustment. Investment and policy-based lending supported quality improvement, capacity building, poverty alleviation, science and technology, and environmental education.

The Bank and environmental education

In comparison with other environmental activities, the efforts of the Bank regarding environmental education and research are less visible. The Annual Operational Review on Education and Training (PHREE, 1992) reveals that the Bank has generally given low priority to environmental topics in educational projects. Bank actions in environmental education have primarily taken place in connection with other (non-educational) projects.

A similar conclusion can be drawn from an analysis of the World Bank projects in Africa for the period 1986 - 1992, (Figure 5) where all the environmental education components are found in sectors other than education (Clausen, 1992).
Figure 5: Sector distribution of the environmental education components of the World Bank projects in Africa (data extracted from Clausen, 1992)
Further analysis of environmental education fields in African projects (Figure 6) shows an accumulation of forestry and agriculture related environmental education components. Comprehensive environmental education and protection programs are rare.

Figure 6: Main environmental education fields of the World Bank projects in Africa (data extracted from Clausen, 1992)
The target audience (might be more than one target group in a project) differs a lot and includes a diverse group of participants ranging from farmers to managers and environmental specialists (Figure 7). The large majority of environmental education activities fall into non-formal or in-service training of selected specialized groups. Pre-service environmental education components can be found in Bank support programs for forestry and agricultural schools and colleges. Only the environmental project in Madagascar has an education/awareness component including the introduction of environmental education into primary school curricula.

Figure 7: The target environmental education audience of the World Bank projects in Africa (data extracted from Clausen, 1992)
Other environmental education activities in the Bank include preparation of regional and general environmental education papers. During the fiscal year 1992 two studies were underway on environmental education in Central and Eastern Europe and in Africa:


- and


A similar study was compiled for Asia in the fiscal year 1991:


Together with present paper (ESP, fiscal year 1993), they contribute to a fundamental knowledge base for further Bank projects.

The Annual Operational Review on Education and Training (PHREE, 1992) has identified an increased demand for policy research, dissemination, and skills training for both Bank and borrower staff - particularly in areas of quality improvement, poverty alleviation, and environmental education. It recommends that science, technology, and environment issues need to be strengthened in the Bank projects. Dissemination, follow-up and development of relationships with organizations more experienced in environmental education are also needed.

Conclusions

1. The Bank supports a large number of environmental activities, from direct environmental projects and environmentally-related elements in different lending operations, to the preparation of country specific, regional or sector oriented environmental studies.

2. A study of Bank activities in Africa indicates that at present most of the Bank environmental activities in developing countries are related to agriculture and rural development loans, followed by energy, transportation, water and sewerage, industry and urbanization projects.

3. Possibilities for introducing environmental issues into school curricula have been overlooked in most educational projects.

4. Bank participation in a variety of education projects in developing countries - from primary to postgraduate levels - presents a unique opportunity to promote the introduction of environmental education. By reaching a larger part of population, such programs would significantly improve the environmental literacy in a country and thus provide long-term support for sustainable environmentally balanced development.
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