ECOLOGY AND EDUCATION:

ALTERNATIVE PROSPECTIVE FRAMEWORK

FOR ECOLOGY EDUCATION

by

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ABSTRACT

The growing concern with environmental problems which has increased since the 60's has initiated the development of numerous ecologically oriented programs in education. Yet, judging by the current ecological conditions it does not appear that we have learned a great deal or been able to make significant progress in the light of what we have learned. Reasons for this state of affairs are given and critically examined. The central question of this study asks, how can ecologically oriented programs best be developed and implemented to equip children with the necessary skills and attitudes to enable them to be more protective of our environment? Specifically, this study examines the nature of ecology within biology education and proposes a prospective framework setting out what ecology education ought to be at the secondary school level in British Columbia.

A qualitative methodology was used to examine the nature of ecology within biology teaching in selected schools. Data and information necessary for answering the research questions were derived from open teacher interviews with twenty secondary school biology teachers, classroom teaching observations, and biology textbooks and curriculum guide analyses. Related literature was reviewed to identify the trends in biology education, and to examine the goals, content, and instruction of ecology within secondary school biology curriculum.

The results of this study showed that there is a serious gap between ecology education as it is represented and understood in Bio 11 & 12 curriculum in B.C. today, and what various educators (including B.C. biology teachers) believe ecological education ought to be. The study also showed a lack of interest in ecological issues by educational policy makers and curriculum planners, which is reflected for example in the small percentage of biology curriculum devoted to ecology, lack of any mandatory course or unit in ecology or environmental education at the secondary school level, and lack of preservice and inservice ecology education devoted to secondary science teachers on a regular basis. The study also found that the status of ecology teaching within secondary school biology curriculum still lacks special focus, regardless of the teachers' enthusiasm and awareness of the importance of this subject within education.

This lack of interest and the gap between what is and what ought to be in ecological education, along with the nature and urgency of the environmental problems, indicates new pedagogical views, structure, techniques and strategies must be developed and infused at all levels (philosophy, goals, content, instruction, etc.,) of the curriculum of ecology education in order to bring about an effect education for and about the environment at the secondary school level.

The study also develops goals, aims, and objectives and proposes a mandatory, yet flexible ecological core content consisting of the history of ecology, basic fundamentals of ecology, human ecology, evolution, ethics of ecology, environmental behaviour, urban ecology, and other related topics. I also consider teaching strategies and suggest that multiple teaching approaches that allow for students' full involvement in the learning-situation should be employed.

Then, I discuss the social environment in which the proposed framework of ecology education, or similar ones can be developed and implemented and then clarify it as an interdisciplinary curriculum using specific criteria. The clarification demonstrates that the proposed framework for ecology education is comprehensive and representative of the high cognitive domain of educational objectives. It is also closely related to the general goals set out for science education in both Canada and the United States.

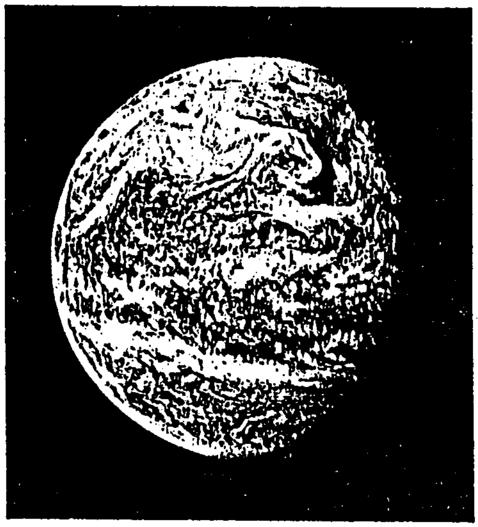
Finally, the study provides thirteen recommendations for the improvement of the ecology education classified under six categories of recommendations.

DEDICATION

To my mother, my father, my wife and my children

And to all who believe in education

QUOTATION



As the century draws to its close, a new cultural and scientific climate is emerging and with it a new solidarity between human beings and nature. These are excellent grounds for pinning our hopes to the future, while remaining fully alert to the uncertainties and dangers of the present.

Ilya Prigogine*

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BACKGROUND OF THE PROBLEM

The General Problem

Although environmental problems continue to multiply at an alarming rate, our education system has failed to develop in students a depth of understanding and concern for the environmental problems the world now faces. The question, therefore, is how to develop an ethos for what is ecologically essential for human well being. Young people urgently need education for ecological understanding and rational environmental action, or what I call " A Productive Understanding" of the environment.

Introduction

In recent years the ecological crisis (ecocrisis[1]) on earth has increased to alarming proportions. In the last few decades, civilization, especially in the industrialized world, has seen an accelerated deterioration of the natural environment by means of mass deforestation, and both water and air pollution. We are also experiencing water shortages, the threat of nuclear destruction, nuclear plant breakdowns, the nuclear waste disposal problems, acid rain and fog, and the threat of the greenhouse effect. As many critics state (e.g., Fedorov,1983), the impact of humans on earth has altered the course of nature in a fundamental and perhaps irreversible way.

The loss of life on our planet due to poor ecological protection should be of universal concern. Even twenty years ago, according to the American Food and Drug Administration, 800 to 1,000 people died and 80,000 to 90,000 people were injured from pesticide chemical poisoning per year (De Bell, 1970). Large numbers of other living species also die each year from the same cause. If pollution, deforestation, and land degradation continue at their present rate, the extinction rate of different species that share

1- The term "Ecocrisis" or Eco-crisis" has been used as equivalent to ecological crisis(e.g. Perelman, 1976). Indeed, Cecil E. Johnson edited a book in 1970 titled "Eco-Crisis".

the earth with humankind is likely to accelerate rapidly. And as Reveal & Brome (1979) put it, the loss of any species which results in the loss of genetic materials in the life system of our environment can never be replaced, even with a highly advanced technology.

The problem, both its cause and its solution, is a human one. Human impact on the global environment has increased sharply. The problem of acid rain[1] and acid fog, both in North America and other industrial countries, continues to grow (Sitwell, 1984). In fact, acid rain, hazardous waste, and the toxic effects of existing chemical and pesticide materials are identified by the head of the Environmental Protection Agency (EPA) of the United States as the three biggest public enemies in the environment of North America (Scholastic Update, 1985). While some of these ecological problems make a dramatic impact, other effects of environmental deterioration are not so easily seen. For example, it took some three decades before research in ecological toxicology discovered that DDT, whose inventors were awarded a Nobel prize, was in fact a danger to natural ecosystems[2]. Another important example is the extensive use of the various Chlorofluorocarbons (CFC's) gases and solvents since World War II. The use of CFC's has improved economic productivity and raised the standards of living in most industrial countries because of its "...low toxicity, small production costs, and efficiency not only in refrigeration and air conditioning systems but also in manufacturing processes" (Crawford, 1986, p. 927). Recently, however, scientists recognized that the use of CFC's poses a potential threat to the ozone layer in the upper atmosphere that protects the earth from harmful ultraviolet radiation (Crawford,1986; Oppenheimer and Dudek, 1987). Thus, ecological deterioration can be seen to have had a profound impact on the quality of life on

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1- Acid rain is caused when sulfur dioxide and nitrogen oxide combine with water in the atmosphere. The sulfur and nitrogen come from burring such fossils fuels as coal and petroleum.

2- According to Christman, et al., (1973) " It has been estimated, that nearly two thirds of all DDT ever produced still remains in the environment, assuming that measuring methods measure only DDT. Most of this will eventually reach the sea and be incorporated into and transferred through the ocean food chain" (p. 152).

our planet. The Canadian Minister of the Environment, the Honorable Charles L. Caccia[1] (1983), succinctly summed it up as follows:

> The environmental issues of today, and our understanding of them, have gone well beyond treating them as simple problems of pollution or inadequate resource management. They are now issues of survival (Cited in Hanson, 1986, p. xi).

Concern for environmental issues surfaced in the late 1960's; we have had a little more than two decades in which to produce results. One of those results has been the development of numerous ecologically oriented educational programs aimed at creating improved awareness, concern, and attitudes towards nature. Blum (1979) reported[2] that in the U.S.A. ecological issues constituted 15% of the science curriculum projects in 1974, but later, by 1977 they comprised 35%. He added that concern in Europe, Asia and Australia was also growing. Cho and Kahle (1984) reported that the subject of ecology in high school biology textbooks has gained popularity in recent years. Countries such as Sweden and Libya[3] have established distinct schools, institutes, and ecological organizations especially for the study of ecological issues and crises, and for the conservation of nature. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has rapidly increased the amount of time, energy, and money used to develop ecologically oriented programs in different countries since 1975 (Hughes-Evans, 1977; di Castri & Hadley, 1980; Johnson, 1980).

But have these ecological education programs produced any tangible results in terms of a better world? Have they increased our awareness of the environmental abuses and limitations of natural resources? Have they changed our attitudes and the way we live?

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1 - In his address to the Research Workshop on Envirorimental Ethics (convened in Montreal, in December of 1983).

2- This was based on the American Science Projects listed in the 9th. International Clearing House Report on Science and Mathematics Curricula Developments.

3- In 1982, the Libyan congress approved the funding and implementation for a new kind of high school of ecology whose graduates will go to a new University of ecology. This new educational system for ecology was scheduled to be in operation in 1986. In Sweden, there are at least ten schools for environmental studies which concentrate on courses for teachers , but work with children as well. This kind of school was started in 1982 by the National Swedish Protection Board (Ludberg, 1985).

Are we now ready to take positive action and become ecologically responsible citizens to save our planet? Judging by the current ecological conditions and the reduction in the carrying capacity of the earth for living species, the answer is 'no'. Although in recent years, concern for environmental education has become fashionable and environmental organizations have multiplied, it is apparent that North Americans continue to pollute and destroy their environment unthinkingly. And consequently, the environment has continued to deteriorate at an alarming rate. Programs for rasing ecological awareness have not been successful, and thus two very broad questions face society: Why have these programs been ineffective in changing our attitudes and behaviour towards the natural world and global ecology? and, why does society not take any action towards alleviating ecological crises until they affect us in our own neighbourhood ponds? The following discussion provides several answers[1].

Lack of Concern Among Ecologists

The scientific community in general, and ecologists in particular, have rarely looked at ecological issues from an educational standpoint. Such lack of concern motivated Bakshi (1980) to argue that, "...a wide gap separated most of the professional ecologists from a large portion of mankind primarily because we, the ecologists, have paid scant attention to the ecological education of the world's citizens" (p. v). The consequence of this shortsightedness, he believes, has resulted in a lack of a true understanding of ecology and eco-ethics among the majority of the world's population. Smyth (1980) postulates that:

1- Some other answers have also been suggested. For example, Frischknecht and Brandenburg (1981-82), say that,
"... the success of these educational efforts has been rather dismal, primarily due to the lack of sound social psychological assumptions upon which environmental education (EE) rests, such as the notion of the information-attitude-behavior link. ... Furthermore, science-related environmental education suffers too often under the syndromes of uncritical selfpraise (little evaluative evidence of effectiveness), pioushopes (viewing science education as the solution to environmental problems); and disciplinary chauvinism (ignoring contribution from other disciplines). ... And last, but not least the staggering scope and complexity of environmental issues have severely impeded the development, implementation, and effectiveness of EE programs."(p. 25).

> Ecologists will...have to look again at the contributions which they have made to general education, especially at the primary and secondary levels where the attitudes of the entire public are being influenced, and consider how they may be developed to meet the needs of the times.(1980, p.53)

Those ecologists who did become involved in educational and social issues most often lacked the necessary philosophical background to facilitate the development of environmentally responsible behavior. Yambert and Donow (1986) contend that ecologists need to understand several basic problems involving the human behavior necessary for developing an effective environmental ethics program.

Ecologists are not alone in this matter. Recently, Pickard (1988) noticed that while the major concern reported in most editorials and letters in many scientific journals are on the social and the environmental impact of technology on pollution, waste disposal, energy, and nuclear power, most of the scientific research being covered in those same journals shies away from such concern. Still, society expects the ecologist to perform the role of mediator between mankind and nature, and to educate the public about the human impact on the natural world. Worster (1987) felt that the ecologist, who is the most recent of science's prophets, "...offers not only a credible explanation for the way nature works, but also something of a metaphysical insight, a set of ethical precepts - perhaps even a revolutionary program "(p. 344).[1] However, if we accept Bakshi's (1980) and Smyth's (1980) claims, then ecological education has not even gained attention from ecologists, the very experts who are the repository of ecological knowledge and expertise. This failure of ecologists to associate education with ecology itself becomes a major problem. The experts themselves seem to need educating so that they in turn can impart their knowledge to the general public through educational channels.

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[1]- Indeed, because of our high dependence on chemicals, one of the social obligations of scientists, whether in academic, industry, or government Bolls (1988) argues is "...the careful categorization of the chemicals we use and the objective and systematics transmission of information about the side effects of exposure to these chemicals" (p. 138). While Schlesinger (1989) would like ecologists to determine and to fulfil their role in the face of global change.

Lack of Concern Among Educators and Philosophers

Educators too exhibit a lack of concern about school ecology and "...philosophers of education have almost totally ignored the ecological revolution as subject of philosophical importance (Calwell, 1982, p. 177). Perelman (1976) describes the educational professional's response to ecocrisis as "parochial at best and self-serving at worst" (p. 197). He contends that both the response of educators and what had been done in the field were grossly inadequate. Many educators tend to move with money he points out. For example, some educational professionals moved on to other fields when the action of the early 1970's (such as Earth Day) cooled and the money dried up. While Schafer (1987) observed that educational administrators place a low priority on environmental education and suggested that research that helps to understand these attitudes and how to improve them is needed.[1]

Partridge (1981) also noticed a remarkable silence from the contemporary philosophers in the 1960's and 1970's, who might have enriched our understanding of the environmental issues through scholarship, dialogue, and education. Those philosophers and educational philosophers who did become involved in environmental issues often lacked the scientific background necessary to challenge the problem sociologically and globally (of course there are always exceptions). Now, some philosophers have begun to join the ranks (Pratridge, 1981). Philosophy departments in some British and North American universities have recently introduced courses dealing with environmental philosophy and issues (Attfield, 1987), and professional journals have now been founded in the area of e.g., Applied Philosophy, Philosophy and Public Affairs. Perhaps this is still too little, too late.

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[1]- Many of the school administrators need to understand the special needs of science and other related subjects for double periods, additional funds, special materials, teaching training, etc. (cf. Hufford, 1989).

Lack of Related Anthropological and Archaeological Knowledge in Ecology Education.

Since environmental crisis is a crisis of culture and social behavior (e.g., Devall & Sessions, 1985), then the need for related anthropological and/or archaeological information in eco-education programs remains acute. Anthropology and archaeology are fields of the study that provide us with important information of what other societies do/did to harmonize or deharmonize their social development with the surrounding environment. For example, "the anthropological definition of ecology includes the consideration of the social and cultural environments of the society, and the adaptation of culture and society to the resources and limitation of the physical environment' (Barnes & Richbury, 1973, p.1). Ethnography or ethnoecology for example, provide us with information about the social behavior of a particular culture, i.e., the natives' view of their own environment and possible practical consequences of it. Paleontology or paleoecology deals with the reconstruction of ancient environments and human adaptation in prehistorical societies. Anthropological and archeological information such as this is not only needed to develop a better understanding of the environment and to improve problem-solving skills through schooling (e.g., Monroe and Kaplan, 1986; Kaplan & Kaplan, 1982; Diamond, 1988), but also to plan and implement environmental societal changes in modern day society (Spradley & McCurdy, 1972). However, the question remains: if information such as this is so important for ecology education, why is there a lack of concern in eco-education toward it?

The answer I believe lies in the lack of awareness of both educators and anthropologists and archaeologists of each other's importance. For example, apart from an interest in methodological issues, educators, especially science educators, have failed to show any concern in what anthropologists and archaeologists have been doing or how their work can be used in environmental educational processes and development. For evidence one need look no farther than at science textbooks, journals, and curriculum guides for the natural sciences and environmental education (Sponsel,1986). And, although there are always exceptions, there is little evidence to indicate that anthropologists and archaeologists have any interest in what transpires in education.

Anthropologists and paleontologists have concluded through cross-cultural studies of the present and past that humans are at the mercy of the natural environment, live in harmony with the natural environment, or attempt to control the whole natural environment including other human beings (Barnes & Richburg, 1973). They also have found that some ancient societies such as the Maori (the Polynesian settlers of New Zealand) or the Anasazi Indians of North America were guilty of ecological failure because of ignorance, while we are guilty of ecological failure because of willful blindness (Diamond, 1988) and a reluctance to utilize knowledge that is already extant. "From now on", Johnson (1985) argues, it may well be the anthropologists among others (such as the historians and natural scientists) who "...have more to offer us in shaping the future than [for example the technologists" (p. 6)

Lack of Emphasis on Teaching Evolution In Secondary School Curriculum

Today, there has been a de-emphasis of evolution in school curricula with a corresponding ineffectiveness of eco-education at the secondary school level. Because of the influence of many non-scientist interest groups[1], North American high school students are learning less about evolution today in the classrooms than ever before (e.g., Skoog, 1979' 1984; Cho and Kahel, 1984). Whatever knowledge or information most of them have comes from out-of-school sources which are based generally on anthropocentric attitudes. Although this is primarily a phenomena in the U.S.A., because a large number of science textbooks (as can be seen in chapter three) are imported from the States, the problem also must be of concern to Canadians. Actions such as these tend to de-emphasize

[1]- Anti-scientist interest groups and their friends were successful in having many teaching materials "... accepted uncritically by the philosophical library" . Unfortunately, "... unlike cigarette packages, it will not bear a warning that its contents are harmful to an understanding of science and that its authorship has concealed its anti-evolutionary bias" (Scientific Integrity, 1988, p.4)..

all subjects related to evolutionary topics and as a consequence lead to poor understanding of the relationships between organisms and their environment.

Because there is a strong thread of common thought between evolution and ecology topics (e.g., Emlen, 1973; Bradshaw, 1984), neither ecology nor evolution makes much sense without reference to the other, especially in the study of biological population, adaptation, or coevolution (Wilson, 1973). Since evolution provides a basic understanding of the fundamental characteristics of life at all levels, ecologists cannot adequately understand the relationships of organisms to each other and to their environment without substantial knowledge of evolutionary theory and population dynamics.

A complete understanding of the behavior of organisms in their environment requires that evolutionary, ecological and genetic principles, concepts and thought come together; something called 'communal evolution' or 'coevolution'.

> Coevolutionary studies have transformed understanding of such economically important topics as pollination, seed dispersal, and epidemiology; and they have many crucial implications for agriculture....Advances in understanding the dynamics and evolution of parasites have put humanity in a much stronger position to deal with horrible problems such as the appearance of AIDS and the resurgence of malaria. (Ehrlich, 1987, p.758)

Since most ecological concepts and principles require evolutionary knowledge, it is therefore important for school children to have the adequate scientific background in evolution that enables them to develop a better understanding of their surrounding environment and how to interact with its components. Teaching ecology without evolution is like building a house on a sand foundation by the sea. It is hard to believe that the erosion in the coverage of evolution in high school biology textbooks published since the 1960's and up to 1983 (Skoog, 1984) started accidently, and I suspect that the move in this direction has its roots in American social mores. It is particularly ironic given that it was in the sixties that the public awareness of environmental problems and human rights were born.

Lack of a Holistic View of Ecology Education

Because the ecological crisis involves them all, ecology education must integrate the social, cultural and scientific domains. It is our social and cultural way of life (ethical, economic, political, aesthetic, and religious) which affect the way we perceive and respond to the physical environment. Indeed, socio-economic and political factors have been the historical forces that have brought us to this crisis with the natural environment. However, we as teachers deal only with the scientific aspect of the environment. The consequences are considerable as Cerovsky (1977) points out: many of the problems now confronting us "...have arisen because scientific discoveries and technology have been applied without due consideration to the social consequences" (p.65). Therefore, to be effective, ecology education programs must also become oriented to the socio-economic and political factors which impinge on ecological questions. Today, only human ecology has attempted to integrate these domains.

Lack of Essential Characteristics Necessary for an Adequate Ecology Education

One of the reasons for the ineffectiveness of existing ecological and environmental school programs is that they do not meet several important criteria necessary for an understanding of how the transformation from ecocrisis to ecological equilibrium can be accomplished. Perelman (1976) argues that this understanding requires more than just the environmental concern of dedicated people and organizations. It requires an ecological education that can meet several important needs generally lacking in most existing educational programs.

Some of the important requirements referred to frequently in the literature, (whether referring to human ecology, environmental school programs, or ecological education (Bybee,1984; Hart,1979; and Perelman,1976 respectively)) are that the programs be multilevel, interdisciplinary, problem-centered, present and future oriented, and have a global perspective. Although, the call for emphasis on these key issues is strong in the literature, little implementation of any of them has been forthcoming (Perelman, 1976; Bybee, 1984). Perelman (1976) argues that prior to the publication of his book *Global Mind*, only a few programs combined two or more of such characteristics, and most involved none. Indeed, he claims that up to 1976, he found no educational program that satisfied all the criteria of an adequate ecological education necessary for the transformation to global equilibrium.

Lack of Its Distinct Place In School Curriculum

Ecology lacks a distinct place in the school curriculum as an individual discipline[1]. Teachers generally try to integrate it and teach it as a part of another subject normally found in the schools. However, many ecologists and educators have argued that the nature of ecology and environmental studies as integrated subjects requires different curriculum strategies and materials from those already used in established school disciplines (e.g. Perelman, 1976; Cerovsk, 1977; Eichler, 1977; Booth, 1979; Smyth, 1980; Harper, 1982). Where ecology is taught, it is generally left to the end of a semester or school year and almost always after the main topics of a given discipline have been covered. And even then, most teachers spend only a few hours teaching ecology as a descriptive subject, instead of spending time identifying principles and concepts.

Although the integration of ecology topics into the school curriculum must be considered a step in the right direction for developing ecological awareness in children, it falls far short of ideal. Where environmental or conservation education has not been a visible priority in public schools, as in North America, its place in the curriculum easily becomes lost and often vanishes altogether.

[1]- In British Columbia, while environmental themes, concepts or topics can be found in prescribed curriculum, "...there is no course, or even a course unit or topic within the entire provincial curriculum that is actually titled 'Environmental Education'. ...To those who feel a strong sense that developing environmental understanding of public schools this is a frustrating situation" (McClaren, 1987, p. 51).

The experience of geography education in the United States is a good example of this phenomenon[1]. During the 1930's geography was taught as a separate discipline at both college and school levels, but in the 1940's and 1950's, the trend was to integrate it into other school curricula. This integration resulted in a loss of geography's place in the curriculum as an individual discipline and it eventually became subsumed by history and current events under the social studies and political science disciplines. Lloyd H. Elliott[2] (1988), wrote:

> There was a feeling in those years that geography was a part of history, that if you were studying the era of Charlemagne, you would naturally look into the geography of that period. So geography was lost....Then sometime during the middle 1970's we gradually realized that we and our children didn't really know much about the world. And we have been struggling to catch up even since. (p. 329b)

Today, many educators speculate that the global and environmental ignorance among many North Americans is one of the consequences of such a loss. What this example tells us is that because of its own evolution and development, there is a limit to how much geography education can be integrated into another discipline, e.g. sociology. Only those very closely related geographical subjects, which foster the understanding of sociology, might be integrated and even these can easily lose their place to any more current sociological trend or topic.

Therefore, since ecology differs by its nature from other natural sciences and ecology education as it has been practised has simply been ineffective as a part of traditional science courses, I believe it is realistic for ecology education to be offered as a special course of study side-by-side with integrating ecological topics into related school disciplines. In effect, ecology would have two outlets, as a course on its own, and as it naturally falls into place inside the other disciplines. For instance, in chemistry

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1- Cf. Fox, 1983.

2- Lloyd H. Elliott (1988), president, the George Washington University, and vice chairman, National Geography Society Board of Trustees, classrooms, it would seem ludicrous to discuss sulfuic acid or sulfur dioxide without talking about acid rain, or carbon and methane without talking about the greenhouse effect .

Lack of Preparation For Action

Ecology education by its nature should concern itself with developing a productive understanding capable of leading to informed decisions, responsible behavior, and constructive action toward the environment. I would argue that behavioral knowledge is inseparable from cognitive objectives in any development of educational processes where the environment is concerned.[1] Environmental education, in short, demands action (e.g., McClaren, 1987). Yet, curiously, ecological programs integrated in school curricula depend heavily on cognitive objectives alone. Indeed, public schools which "...are extremely wary of action [seem to forget that]... there are things to be learned through action that can simply not be learned in any other way "(McClaren, 1987, p. 55).

Cognitive objectives, rather than effective or skill behavior objectives, have attracted attention for years in environmental and conservation education. As a consequence, preparation for action has not as yet found its place in curriculum content and the teaching of ecology.[2] Providing ecological knowledge and developing environmental awareness to act willingly and responsibly differs from simply providing students with factual knowledge.

Ecology education and related programs must be concerned with developing among students the ability to engage in responsible environmental behavior in a productive manner (or what I call productive understanding) as one of its objectives. Children, especially those in societies where economic decisions are based on anthropocentric market considerations, should be prepared to take responsible action in order to bring about change

1- Many educators have argued so, such as Eichler, 1977; Hart, 1979; Hines, Hungerford, & Tomera, 1984; Krathwohl, et. al, 1964.

2- Indeed, Hine, Hungerford, and Tomera (1984) found empirically that curricula and instructional strategies which " ... effectively lead to the development of environmentally responsible individuals have not been implemented in our [American] school system" (p.1).

in the care of the environment. In an environment which lacks this understanding, apathy becomes the standard reaction to ecological issues. I believe ecology education must aim toward developing a productive environmental understanding. By this I mean the intellectual capacity to grasp the ecological concepts and principles, and the behavioral capability of continued willingness to act on these concepts and principles for the betterment of the environment and the quality of human life.

Difficulties In Teaching Ecology

The teaching of ecology seems to present difficulties for most biology and other secondary school teachers. I will go into the reasons in depth in chapter three, but the main reasons put forward in the literature are: the nature of the subject; confusion about how to teach it; lack of appropriate materials and equipment; lack of confidence among teachers in dealing with ecological issues; lack of appropriate linkage in teaching between practical and theoretical ecology; lack of emphasis on observation in science teaching; and insufficient teacher education in teaching ecology.[1]

Another strong reason why the teaching of ecology is not considered as important as most other subjects stems from the fact that ecology and environmental subjects are not only electives, but are not included in the provincial and scholarship examinations at the secondary school level. It is widely believed that both teachers and parents value aspects of the curriculum only insofar as they are assessed by examinations; anything not in the final examination is considered marginal information by both teachers and students. However, regardless of the fact that we have a remarkable capacity for ignoring information that cannot be accommodated within our interests and goals, the testing and evaluation programs which force teachers to focus on examinable aspects of the curriculum rather than

[1]- Doubtless some examples of such teaching can be found in different schools, but Booth (1979) adds that, " in general there are few schools with a planned programme aimed at developing ecological understanding amongst all its pupils "(P, 264).

the needs of students are part of this problem. Parents are not very different from teachers in this respect. Eichler (1977) recognized this ten years ago when he wrote:

> As to the values at present prevailing at the secondary school level, parents tend to attach greater importance to the passing of examinations than to other more far-reaching aspects of their children's education. If environmental education subjects were included in secondary-school examinations, parents would also become more interested in this theme. (p. 107)

Thus, I agree with Booth (1979) who sees that the problem will not be solved and much ecology will not be taught unless examinations and their syllabuses demand that ecology be an integral part of science courses, that it be mandatory in science education, and that it be about the real world, including what is happening now in human society and the natural world.

Whatever the cause for the lack of ecology education, mankind is living in a period of ecological crisis so great that it is imperative something be done while there is still time. Without education however, I believe that it is impossible for human societies to effect any change. A call for education programs that might produce a degree of environmental sensibility and responsibility among future generations of decision makers was one of the main recommendations of many national and international conferences on the environmental issues and global earth. Many have suggested that education holds the key for developing ecologically literate citizens, solving ecocrises and preventing new ones, and maintaining the global ecological equilibrium.

What Role Can Education Play?

Despite the existing conditions of world ecology and limited effectiveness of past ecological programs, education remains the best hope for planetary survival, welfare, and development. Human history testifies that education (either formal or informal) has been the key, not only to human progress and civilization, but to the development of the individual. Beyond education of course are other forces of change in society such as politics, economics, ethical, and other social and cultural forces which could play an important role in fostering positive ecological attitudes. Policies and laws alone, however, cannot be a major force of change. They do not educate people so that they will understand, for instance, that the solution to acid rain, the greenhouse effect or the ozone layer might be a total change in economic and energy policies. It is generally accepted that:

> Governments and policy-makers can order changes, and new developmental approaches can begin to improve the new world's conditions -- but all of these are no more than short-term solutions, unless the youth of the world receives a new kind of education [education that focus on learning and developing creative, critical thinking, and problem-solving skills]. (Unesco-Unep Newsletter, 1976, p.2)

Responsible decision-making can only arise from a productive understanding and a solid foundation of integrated knowledge that covers all aspects of a given problem.[1]

If one of the root causes of our environmental crises is our life style which we choose by our act of will and which can be altered by our conscious choice (Levins and Lewontin, 1985) then education may help us understand the need to adapt a style of living that harmonizes with the environment. In making appropriate decisions, one must have both a productive understanding and specific knowledge. Institutional education can provide[2] the knowledge, understanding and skills necessary. However, this must start in the early school years. After all, "there can be little doubt that understanding ecology is of critical importance today...nor could there be a clearer challenge to education, for survival certainly hinges upon an informed citizenry" (Pasquino and Peelile, 1975,p. 487).

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[1]-Otherwise, I believe, there will always be conflict between individual and group interests in the implementation of laws or policies.

2 However, there are some educators who are skeptical about the effectiveness of schooling in changing people (Etzioni, 1968, 1973; Kennedy, 1983; Schelling, 1980). Nor does school exist in a vacuum. It exists in society. Politics, economics and social order are some of the major forces of change. "If certain powerful groups which control or impede change oppose a particular solution [or change] then it probably will not be undertaken regardless of its effectiveness" (Kennedy, 1983, p.55). Coordination and cooperation of socio-economic and political institutions of a given society are necessary conditions for effective educational planning and implementation.

The Aims of This Study

This study aims to analyze the nature of ecological education in selected senior secondary biology classrooms, to determine what ought to be the nature of ecological education, to identify the discrepancy between ecology within biology education today and what ecology ought to be, and to develop a prospective framework for ecology education. The potential achievement of these aims will record whether the teaching of ecology in high school science classes reflects the perspectives that emerge from the literature on ecology education. If the teaching of ecology does not reflect these aims, then, perhaps the lack of concern and understanding of ecological problems in society is a function of inadequate ecological education and therefore, we should consider the literature and the research results in developing ecology education programs. On the other hand, if the goals, content and instruction do reflect the view of ecological education gained from the literature, then, perhaps other factors prevent or hinder ecological education from promoting environmental concern and understanding in society. Thus, the study will provide us with an indication of how the ecological content and the teaching approach reflect the goals of ecological education.

An Overview of This Study

Chapter Content

The first chapter of the study outlines the general problem, provides a background of ecology education, the aim and an overview of the study and its methodology. The second chapter deals with current major trends as seen in the literature in biology education within which ecology is housed.

The third chapter provides background information that helps to identify what the nature of ecology education ought to be at the secondary school level. It reviews related literature, focusing on the goals, content, and instruction of ecology within school biology. The fourth chapter covers the research methodology, which includes methods of data collection (classroom observations, teachers interviews and biology textbooks and curriculum guide examination) and data analysis.

The fifth chapter provides empirical information concerning the nature of ecology education today. It covers data collection, analysis, and the results of the analysis. The sixth chapter examines the 1986 Biology 11 & 12 Curriculum Guide and the two required biology textbooks which represent the backbone of biology curriculum at the secondary school level of British Columbia. This chapter also discusses how biology and ecology are being taught in observed biology classes and as well discusses the nature of ecology education today at the secondary school level of British Columbia.

The seventh chapter provides a prospective framework for ecology education based on (a) the review of related literature, and (b) a panel discussion of scientists, science educators, curriculum theorists, and faculty associates. The eighth chapter discusses the mechanism of the proposed ecology education curriculum and evaluates the entire proposed framework. The final chapter covers the summary, conclusion, and recommendations of the study.

The Target Population of This Study

Even though I am convinced that ecology education must be a continuous, lifelong process, both in school (K-16) and out of school, in order to achieve the main goals of ecology education, the following reasons explain the choice of secondary school as the target population of this study.

(1). Secondary school students are at an age which enables them to understand multi-dimensional problems and to take action. They are also more objective and analytical towards society's beliefs than are primary school students. In addition, secondary school students are, or will in a short time be, voters and taxpayers. Therefore, educating them ecologically will obviously affect their choices in the future. They will become members of a concerned public to whom the policy and decision-makers will have to respond.

(2). The secondary school level "is the last at which the formal school system has an opportunity to try on a massive scale ... [to make changes in a large proportion of the citizenry]...with respect to knowledge, thought processes, emotions, and values" (Kolb, 1971, p.214).

(3). With all the documentation on environmental education assuming that ecology is an essential part of the education of all pupils (Booth, 1979), little has been done at the secondary school level regarding ecology education.

An Overview of The Methodology

The methodological framework of this study involves three main steps: I first developed a framework for ecological education by reviewing the related literature and discussing it with a panel of scientists, science educators, curriculum theorists, and faculty associates (Historical and analytical/developmental research). This provided one possible model of "what ought to be" in terms of the content and instruction of ecology education. I then collected data through classroom observation, teacher interviews, and biology textbook and curriculum guide examination about the current status of ecology education at the secondary school level(Descriptive research). Finally, I then compared the "ideal" framework with the empirical data on teaching in order to identify the discrepancies between "what is" and this particular view of "what ought to be" (Comparative/analytical research).

In the chapter that follows, I examine the ecological education literature regarding the trends of biology education as well as the goals, content and instruction of ecology within biology education.

CHAPTER TWO

TRENDS IN BIOLOGY EDUCATION

In this chapter I examine the major tecological rends in biology education (within which ecology is housed today) since the turn of the last century[1]. These major trends are: a movement from anthropocentrism to ecocentrism; from reductionism to holism; from competition to mutualism; and from a local or global to a local/global perspective. I refer extensively to the works of Worster (1987), Young (1986), Swan (1985), Berberet (1984), Stone (1984), McCrea and Weaver (1984), Sessions (1983), Barber (1982), Worthington (1982), Wert & Quick (1977), Zais (1976), Marx (1974), Dede and Hardin (1973), and Olmstead (1967), as well as the literature on historical ecology with which I begin this chapter.

HISTORICAL BACKGROUND

Ecology has been a matter of human attention at least since the time of Aristotle (384-322 B.C.). The foundations of modern ecology, however, were laid down with Alexander van Humboldt's Cosmos (1845-62) and Charles Darwin's *Origin of Species* (1859). In 1886 the word "ecology" was first defined by Ernst Haeckel in his famous *Natural History of Creation* .[2] Since then ecology and natural history have been used interchangeably until the end of the last century when ecology emerged as one of the major

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1- This time is chosen as a starting point, because: (a) Ecology emerged as a separate field of study in the late 19th and early 20th century (Worthington, 1982). (b) The nature-study which was associated with the educational reform movement of the early 1900's "involved methods different from any used previously as well as the use of new views of the child, education and science" (Swan, 1985a, p.11). It brought science for the first time into common schools, especially elementary, through focusing upon experimentation and problem-solving skills. (c) The 1900's is the period of time during which North America experienced a mass immigration of people with different cultural and philosophical backgrounds. As a result of this and the ecologically harmful behavior of the immigrants, the natural environment suffered greatly. (d) It is during the early part of the 20th century that conservation and the environmental movement became active, and conservationists realized the importance of physiology and the chemistry of the environment in understanding nature (Barber, 1982; Cellarius, 1987).

2 - The need for environmental understanding and ecological harmony were observed in the works of many profound Western philosophers such as Aristotle, Plato, Francis Bacon, Russio, to name a few.

branches of the biological sciences.[1] Indeed, it is only within this century that ecology has become a recognized science, thanks to the work of many geographers, biologists, and ecologists, such as Vladimir I. Vernadsky, Eugenius Warming, Frederick Clements, Arthur Tansley, Victor Shelford, Lamont C. Cole, Fraser Darling, and Eugene Odum, to name a few, who outlined many ecological themes with which ecology enters its modern, mature stage.

Worster (1987), however, argues that the real age of ecology began with the first nuclear fission bomb detonated in the desert outside Alamogordo, New Mexico on July 16, 1945. On that day, he adds, concerned scientists and citizens realized for the first time in human history that "...there existed a force capable of destroying the entire fabric of life on the planet. As Oppenheimer suggested, man, through the work of the scientist, now knew sin. The question was whether he also knew the way to redemption" (Worster, 1987, p. 339). As a consequence, many concerned scientists, especially biologists, began a campaign of information and protest to warn the public of the dangers in further nuclear testing; dangers which could mean irreversible genetic damage and the extinction of living things, including mankind, everywhere in the world. But the truly unique feature of the age of ecology according to Worster (1987) "was its sense of nature as a defenceless victim" (p. 341).

Since the beginning of the twentieth century, ecology has undergone a radical transformation, passing through three distinct stages. According to Worthington (1982), the concern of ecologists started with an exploratory emphasis on the distribution of plant populations, then shifted largely to descriptive emphasis on distributions, adaptations, and life cycles of living organisms, and later into a more experimental science[2] . Today, in the

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1- In this early development, ecology was static, purely descriptive, and used unstructured observation of the living world. These sorts of ecological activities made early field-work of ecology to some extent a sterile subject.

2- However, both E. Goldsmith (1985) and D. Simberloff (1986) suggest that as a result of the transformation of ecology to experimental science, mainstream scientific ecology no longer reflects the early natural world of ecology (Goldsmith, 1985). But on the other hand, there are some researchers and ecologists who argue otherwise.

fourth stage (the last few decades), many ecologists try to incorporate ecological principles and concepts into human life and social affairs. Still, Worthington (1982) argues that the focus of present ecology remains descriptive and experimental and will doubtless continue to do so at least into the next century. He hopes that future ecologists will try applying what they already know to the economic, social, and aesthetic improvement of human beings and global ecosystems. It seems to be fairly generally accepted that in order to be accepted by the public, ecology requires a new image that takes it beyond the physical aspect of the environment. Ecology also needs to shift its concern for untouched nature (typified by a study of the pond) to a focus on real world ecosystems including villages, cities, and the global ecosystem, as well as the human being as a component of this ecosystem.

Today, ecology is a well defined scientific discipline, at least in higher education[1]. It occupies an independent class of researchers and an influential position among the sciences (Worster, 1987). At the college and university level ecology is not just a discipline in itself, its concepts are found in many other disciplines as well. Yet, the fact remains that even now, when ecology has become in many ways fundamental to biology and its associated subjects (Wells, 1982), ecology has not been incorporated into school curricula even as an aspect of biology (Smyth, 1980). At the secondary school level, ecology is still an unpopular subject, not just among students, but also among teachers.[2] Where ecology has been recognized and studied, in most cases, it is pushed into , "an insignificant corner of the curriculum occupying the last week or so of the summer term" (Dowerwell, 1979, p. 294).

1- Ecological ideas and principles have already extended to areas of knowledge beyond biological and ecological science. As early as the 1900's, ecological ideas and concepts have found their way into most disciplines concerned with human societies. According to Borden (1985) by 1975, "ecology in some form or other had found its way into nearly every academic field from literature and music to architecture, economics, engineering, political science, and psychology "(p. 2). Yet in secondary school education ecological concepts and ideas seem to have a long way to go.

2- Even ecological field work which is supposed to reflect the true nature of ecology, is often based on a systematic approach (taxonomic and reductionist). This approach represents the early pre-theoretical sterility of the subject regardless of the substantial theoretical framework of ecology (Hill,1986) .

Trends In Biology Education

As I stated earlier, ecology in biology education appears to be changing from an anthropocentric viewpoint to the ecocentric; from the taxonomy-reductionist approach to the holistic; from competition to mutualism; and from a local or global perspective to a local-global as they apply to ecology and environmental issues.

From Anthropocentric to Ecocentric

An anthropocentic perspective considers human first and foremost while nature is a God-given gift to be utilized. On the other hand, an ecocentric perspective views man "...as just another species in the natural web, having no special claim to the resources of the earth, certainly no claim to control or exploit them, and decidedly no right to threaten their very continuation" (Sale, 1986, p. 26)[1] .

Anthropocentrism: As early as the 1900's, both the nature-study and conservation movements furthered an anthropocentric view of human and nature, and many educational programs have continued to do so. For example, at the turn of this century, although nature-study involved new views of the child, education and science (Young, 1986; Swan, 1985a,b), it did not deal with any comprehensive environmental theme or controversial issues, nor did it emphasize the understanding of scientific principles (Balzer, 1971) necessary for grasping human's place in the natural world. Humankind and its impact on natural resources and the delicate structure of the ecosystem were in some way excluded from the conservationist thought of the 1900's. The ecological concepts which arose out of the interest "...in study of and aesthetical/inspirational aspects of nature" (Cellarius, 1987, p. 219), were influenced by a conservationist view of the 1900's which was exclusively interested in reserving wildlife (especially game) for their beauty and benefit for the people of the present generation, rather than for the preservation of the natural world for its own sake. Gifford Pinchot, the founder of the U. S. Forest Service in 1905, and a friend of

1- Cf., e.g., Devall & Sessions, 1985; Devall, 1988

Teddy Roosevelt, is a good example of the conservationist thought of that time. Pinchot's conservationism advocated the development and use of the earth and all its resources without serious consideration of the impact of maladaptive behavior on the delicate structure and interdependence in the ecosystem (Sale,1986). Since then, Pinchot's conservation has "...dominated most official thinking, much academic research, and almost all governmental actions throughout this century" (Sale,1986, p. 26). Even those conservation groups which were able to act as scientific research and educational organizations were somehow prevented from doing so. For example, The Canadian Commission of Conservation was dissolved in 1928 when it tried to extend its jurisdiction to executive function and thus it failed to have much effect on educational, economic or political aspects of social life (Manzer, 1985). In 1946 the Ecological Society of America ceased in active preservation efforts (lobbying for policy and legislation) and acted only as an advisory agency for scientific research (Blair, 1986), something which led some concerned ecologists (e.g. Victor Shelford) to form a new ecological organization.

Science innovation in the 1930's (such as antitoxins, vaccines, vitamins, river dams, irrigation, and hydroelectric power) also furthered anthropocentricity by strengthening man's belief in the possibility of perceiving, improving, and adapting the world to human needs. Man's faith in science and technology and the belief in the right to use the natural world for human benefit became deeply entrenched in the consciousness of many North Americans. Also so, many people pursued Francis Bacon's dream of extending man's empire over nature as a goal. Consequently, industry came forward to play greater role in academic research and school curriculum (Zais, 1976; Young, 1986). Indeed, one of the main goals of the public school system was seen to remove the obstacles on the road to material success and developmental progress in the society (Greene, 1985).

The trends of science education in the two decades following World War I shifted to practicability, and textbooks addressed this shift by emphasizing the relationship between plant and animal classification and the nation's economy. Textbooks also provided some information about landscape, home gardens, destroying flies, etc. as a necessity for a good life but with no consciousness of man's place in, or impact on, the environment. Such a perspective remained in the shadow of anthropocentric domination until the early 1960's,[1] in spite of the the growing concern among biological community to introduce alternative ideas regarding the place of human beings in the natural world.[2] Yet today, many still argue that school curricula, including biology, are still being designed in such a way that prevents students from learning about themselves, other people (Lipka, 1981; Arnsdorf, 1972) and the human place in the natural world (Hurd,1971). Stone (1984; 1985) argues that views such as anthropocentricity have dominated high school biology textbooks for a long time. Since many practioners have perceived textbooks as the backbone of the curriculum, and teachers and students still place a great deal of reliance on what textbooks tell us, we are inclined to see nature and its components the way we are taught to see them-in an anthropocentric way.

Ecocentrism: The idea of ecocentricity, or balance in nature, was reborn in 1939 when concerned biologists started questioning anthropocentricity. Frederic Clements and Victor Shelford originated the notion of "biome", in which all living organisms, including plant, animal, and human communities, played an important role in understanding the need for, and the merit of, an ecocentric perspective. This notion of biome brought to the attention of several early ecologists, the realization that every civilized man or woman was part of the ecological community. But in the North American grassland, it was clear to Frederic E. Clements that the white man who disobeyed the natural laws could not be considered a member of the biotic community because he came as an exploiter of the biome and the natural pattern of succession (Worster, 1987). The transformation of the American

1- In spite of the progress of outdoor education after World War I (Swan, 1985).

2-Osborn wrote in 1948, "It is amazing how far one has to travel to find a person, even among the widely informed, who is aware of the processes of mounting destruction that we are inflicting upon our life sources" (cited in Stone, 1984, p. 194).

forests and grasslands to the Dust Bowl of the 1930's in only a few years, is a good example of what Clements refers to. But it was this Dust Bowl, as Worster (1987) noticed, which, "succeeded dramatically in bringing the young science [ecology] out of the academy and into public consciousness" (p. 220), and led to conservation education being required in some schools in the U.S.A. (Kolb, 1971). It was clear to many ecologists by this time that "...it was no longer possible to leave [hu]man out of their textbooks and models" (Worster,1987, p. 219). Thus, the Dust Bowl experience, Worster (1987) explains, was one crucial factor in the rise of a new philosophy of conservation that looked at ecology as the basis for a new relationship between mankind and the natural world, and for a new environmental ethic, especially through the work of Aldo Leopold, the father of wildlife management in America.

Soon after Leopold's famous 'Land Ethic' in '*Sand County Almanac*' (1949), the idea of "ecocentricity" and the biocentric resource management perspective became an issue to some concerned biologists. Leopold stressed the balance of nature as the basis of his philosophy when he described all in nature to be interwoven. Along with some other early academic ecologists, Leopold saw nature as a perfectly designed world to satisfy, among other things, "the needs of its component population, societies and individuals of what ever species" (Goldsmith, 1985, p. 90) not just the human species. Leopold realized that, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" Interestingly, soon many concerned biologists responded positively to Leopold's idea of ecocentricity, and the biocentric resource management perspective became a social issue to some of them. Those new 'ecocentric biologists' called for the inclusion of more ecology and evolution in biology education. They demanded that biology textbooks be written from the ecocentric emphasis. Unfortunately, with only a few exceptions such, as Alfred Kinsey in 1933 and

1938 (Stone, 1985), most authors of biology textbooks did not follow through with this new idea.

In the fifties and early sixties, the resulting increase in use of natural resources led many concerned citizens to realize that North America could no longer remain the land of endless natural wealth without employing conservation methods and ethics (Swan, 1985a). Concerns about whether a method to manage an ecosystem without destroying the food, air and water supplies were raised.[1] Concerned scientists, writers, and thinkers increasingly realized that anthropocentric activities in the ecosystem were a part of the problem. For many concerned people, reforming the present technocratic society by changing resource management in a biocentric direction and channeling education in an ecology-minded direction, was a part of the solution. Schooling was seen as one of the key instruments for people to learn how to sustain themselves and their environment in a healthy way and to facilitate their personal development. In the United States, governmental aid and direction were given for intervention in the school curriculum to enable society to attain world technological dominance (Wert & Quick, 1977). As a consequence, scientists began involving themselves in curriculum planning for the first time, and a revolution in ecological and environmental concern began during the mid-sixties. The newer textbooks were forced to respond to this revolution and to focus on basic ecological interactions.

But it was the curriculum reform movement of the 1960's, funded by the National Science Foundation (NSF), which led to fundamental changes in content and methods of teaching biology to fit the demands of society and the needs of pupils. Production,

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[1]-Many non-formal educational publications promoted this concern among the public, including scientists, and policy makers. Some of these are: Silent Spring by Rachel Carson in 1962 which urged governments to initiate action to protect the environment from the impending threat; the Scalped Earth by Mrs. Lenkown, in 1962, a remarkable work on environmental deterioration and the consequent dangers which alerted the layman to these environmental issues, and promoted his awareness; Man and Environment, by Robert Arville in 1967; and Nature In Danger, by Jean Dorst, in 1965, which has been described as the bible for contemporary environmentally oriented conservationists because of its broad and deep impact on world public concern. Also, Planet in Peril, by R.F. Dasmann, in 1972 (in French); Only one Earth , by Barbara Ward and Rene Dubois in 1972; among others.

consumption, physiological relationships, and environmental concepts, as well as natural history were addressed in biology textbooks developed by Biological Sciences Curriculum Study (BSCS)[1] the project funded by NSF. Regardless of the fact that the BSCS biology textbooks did not emphasize social problems (Bybee, 1979 b), they were the best biology texts available even to this day from the standpoint of how they dealt with environmental issues academically as well as philosophically.[2]

The middle of 1970's witnessed the waning influence of scientists, including biologists, on school curriculum. By 1975, biologists in the United States lost the power and support they had gained during the 1960's. Perelman in 1976 wrote in his book *Global Mind* that:

> There is virtually no money available for curriculum development in most of the component areas of ecological education, nor in ecological education as a whole. In fact, funds for curriculum development in postsecondary education generally are scarce, especially for such major developmental efforts as are required to create an adequate ecological education (p. 257).

The research on social and environmental issues in science education which reached its highest peak years in the early 1970's had also declined (Rosenthal,1983).

Due to a lack of federal funding and the influence of special-interest groups, not only did the anthropocentric viewpoint reappear in biology textbooks, but it became hard for publishers to sell biology textbooks which reflected an ecocentric philosophy [3] (Stone,1984; 1985). This might explain why there is a lack of adequate emphasis on social

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1- Interestingly, Kolb (1971) noticed that the first high school biology textbook that was based on an ecological approach, was an exception among the other traditional ones during the early 1960's.

2- That superiority may have been due first of all to the fruitful cooperation between prominent research biologists, and high school teachers, as well as to the contribution made by about 1,450 schools and over 150,000 students through their use of the trial materials from 1960-1963. Second, all the BSCS texts, especially the Green Version, included ecological topics and were written from the ecocentric viewpoint. Third, the BSCS authors were free from special-interest groups and commitments.

1- The situation became worse when some of the special-interest groups (who are variously anti-science, creationist, anti-abortion , pro-industry, anti-vivisection, and so on) began to accuse some of the environmental organizations and ecologically concerned citizens (professionals and laymen) of being anti-progress, development and civilization.

and environmental issues in most biology textbooks in use in North America today. Or, as Stone (1985) puts it, while ecocentric viewpoints start to disappear, dissecting frogs and teaching the mouthparts of the grasshopper and the appendages of the crayfish are making a strong comeback; something which was common in the teaching of biology up to and including the 1950's.

Thus, despite biology textbooks published between 1900 and the 1960's reflecting a growing interest in environmental concern in North America, the anthropocentric viewpoint toward nature dominated most of those texts. By the 1960's and early 1970's , scientists and biologists had involved themselves in curriculum planning and had gained support and control of the curriculum. BSCS, especially the Green Version, which was written from the ecocentric viewpoint, was the best example of the involvement of scientists and science educators in school curriculum. Indeed, many textbook authors and publishers adopted BSCS's ideas and published texts reflecting the ecocentric viewpoint. Yet by 1975, scientists and biologists who have the understanding and the broad conceptual overview required for improving school science curriculum, lost government support and the power over curriculum they had gained in the 1960's regardless of the influence of the (a) call for the development of environmental literacy by the President of the U.S.A in 1970, (b) the signing of the Environmental Education Act of 1970, and (c) the first national Earth Day on April 22, 1970. Thus, regardless of concern about environmental degradation in North America, society "has not come to a consensus about the appropriateness of environmental content [and thought] in the curriculum or the role of schooling in reconciling nature" (Young, 1986, p. 231-232). The anthropocentric viewpoint reappeared in biology education by the 1970's, and most ecocentric textbooks written by the BSCS authors were left on the shelves in many parts of North America. In British Columbia, Canada for example, BSCS Green Version which is an ecologically oriented biology textbook was replaced in the mid 1980's.

Reductionism Versus Holism :

As an integrative discipline (Odum, 1977), ecology requires holistic thinking and an approach capable of penetrating various disciplines to link together various related ideas. Yet, the history of science and science education shows that the reductionist approach (breaking things down into smaller units for close study) dominates (e.g., Linn, 1987). Indeed, Goldsmith (1985) claims that holism which is at the very heart of ecology, becomes today "...unacceptable to science and to modern industrial society without which there would be no science..." (p. 91).

While reductionism offers a powerful tool in advancing a particular form of understanding, it fails to provide the best method for answering all biological or ecological questions. Critics argue that reductionism does not use history and philosophy in biological and ecological explanations; the history of science testifies that scientific methodology alone can not guarantee reliable explanations of a given biological or ecological phenomenon (Hill, 1985; 1986). Reductionsim might not explain the interrelation of different sorts of phenomena that make up the totality of a given natural system or the relationships between human beings and the natural world. When we reduce the whole into parts for study, we tend to lose sight of the larger patterns and cycles that connect all things on earth. Ludwing (1985), among others, sees reductionism as inadequate for students viewing themselves, and their life processes, as a part of the overall environment[1] . Reductionism tends to narrow the student's view of science and

1- Throughout this century and in terms of science curricula, science courses have been identified by specific subjects, such as biology, chemistry, physics, and earth science. Since the 1900's these separate disciplines have been divided up and changed to such an extent that it now takes nearly 7.000 journals to cover research in these fields (Hurd, 1986). In terms of holistic thinking and approach, these divisions narrow students' view of science, and are totally inappropriate for understanding the ways in which science and modern society interact. However, the situation within a single science textbook (e.g. biology) in modern education is not different. The chapters or unities in many textbooks lack an adequate connection between each other.

ecology[1] , and therefore is insufficient in itself for understanding the ways in which science and modern society interact in the global ecosystem.[2]

In order to understand a system, we need both reductionist and holistic properties (Allen and Starr,1982). These properties complement each other, and have an important implication for the study and teaching of science, and particularly ecology. To conclude, it has been widely accepted that the holistic approach in science teaching is one way of developing an ecologically oriented mind necessary for solving ecological crises and preventing new ones. Yet, the traditional philosophy of reductionism remains dominant in both the study and teaching of science (Reese, 1978; 1984). As Ludwing (1985) wrote, "perhaps by simple intellectual inertia,...even advanced texts of the time presented ecosystems as sums of component parts...they explained the pattern but not the process" (p. 24). However, it is the holistic approach which brings together science, society, nature and people (Hurd, 1986) and in turn promotes understanding of the interdependence of science, technology, culture, and society; the trend which traditional school science has ignored.

From Local or Global to A Local-Global Perspective:

Ecological issues and environmental problems are global concerns whether or not they have a direct impact on a given local environment. Nitrogen oxides and sulfur dioxides for example, can spread into the air from British industries and reappear as acid rain in Norway and Sweden. Starvation can occur as far away as Ethiopia, but affect the

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1- The divided perspective has not just isolated biology topics from each other, or biology as a course from the rest of science courses, but has also isolated science from social, cultural, and economic human activities. Science and social sciences as well as human beings and nature are inextricably intertwined.

2- Biology in general, and ecology in particular, should be holistic, and even when certain areas have to be studied separately, they must be studied in the light of the whole ecosystem. The whole human body, for example, operates to keep the human functioning and alive, thus parts cannot be studied without recognition of their function within the human system. However, we persist in reductionism, studying leaves, branches, stems, and roots and then trying to assemble these into trees. It is the study of " ECO"="Oikos"= "House" or ecology, which leads to an understanding of the environment to which human beings belong through life processes. However, rather than holistic education, the study of ecology and ecological systems in biology remains reductionist.

pockets of Canadian taxpayers. Therefore, even if we cannot act globally, we should at least teach our children to think globally; at least then their local ecological actions might have a global impact.

National and international science educators consider teaching global problems in school very important (Bybee, and Mou,1986; Rosenthal, 1985). Yet such teaching does not occur. Rosenthal (1984, 1985), in her study of 22 high school biology textbooks published between 1963 and 1983, found a lack of a global perspective in the treatment of social issues. She concluded that these texts give, "little recognition to how current issues impinge on the lives of people outside the United States, or to how the lives of people in the United States are influenced by conditions in the rest of the world" (1985, p. 462). British educator, Carrick in two studies of 20 biology textbooks, published between 1972 and 1982, found that many of these texts paid no attention to global biology (World Biom). Furthermore, Bybee and Mau (1986) who surveyed 262 international science educators representing 41 countries, found that they believed the most significant limitations to implementing the teaching of global problems related to science technology and society are: "political, personal, social, psychological, economic, pedagogical, and physical" (p. 599). Rosenthal (1985) summarizes this problem suggesting that this is not because of the nature of social issues alone, but also because of the lack of a global perspective of the author(s) of textbooks.

Historically speaking, the lack of globalism in biology education has been noticed at least since the 1900's (Stone, 1984). However, BSCS textbooks of the curriculum reform movement of the 1960's came out with a fundamental change not only in content and instructional methods, but also in national and international perspectives. This may be, in part , because of the NSF funded projects to produce more competent scientists; the influence of Sputnik (a successful major foreign project) on public attitudes; and the influence of the human rights movement in the late 1950's and early 1960's. In this movement, some believe that many norms and social standards were subject to question including education as well as human thought and action toward other people, societies, and the natural world. Yet, in the 1980's, Rosenthal (1984; 1985) found a lack of globalism in biology education. We live in a global world that requires we have a global view which in turn requires that we know more about the world around us (geographically, historically, socially, politically, etc.) than at any other time in human history.

Mutualism Versus Competition*

Emphasis on competition and predator-prey interactions have dominated topics related to existence and survival relationships among living organisms in biology and ecology textbooks at both the college and school level. On the opposite side, however, mutualistic relationships have received low emphasis. Mutualism is a form of symbiotic relationship in which two or more species live in intimate relationship with each other, either facultive or obligatory, to the benefit of all. Competition, on the other hand, is the "use or defense of a resource by one individual that reduces the availability of that resource to other individuals" (DeSanto, 1978, p. 234). There is speculation that the emphasis on competition rather than on mutualism has, whether directly or indirectly, strengthened the belief that balance in nature can be achieved and maintained only through competition.

From Thomas Malthus and Adam Smith to Charles Darwin and Herbert Spencer, the idea of competition began to be seen as an important factor in nature, a basic element in the universe, and/or the ultimate source of human progress (Boucher, 1985). Human progress through competition has become the dominant theme in both the natural and social sciences ever since the 19th century. Even Frederick Clements (a dominant figure in American ecology in the early twentieth century) and his British colleague, Arthur G. Tansley, devoted little attention to non-competitive kinds of relationships among living organisms. In short, regardless of the balance that may exist in nature, up to the early

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*Some of this section has been submitted to the journal of *The American Biology Teacher* under the title of "Mutualism: The forgotten concept in teaching science".

1970's most ecologists represented it as being maintained by competition for resources, such as shelter, food and energy (Boucher, 1985), and mutualistic relationships between species were seen as quaint biological curiosities (Starr and Taggart, 1984).

The continued emphasis on competition has pushed mutualism out of favour in modern ecology teaching (Boucher, 1985). Yet, as Risch and Bourcher (1976) notice

> Twentieth century ecology, while usually shying away from analogizing the natural and social worlds, has continued the tradition of seeing antagonistic interactions as the basis of community organization. Its development of theoretical bases in the twenties and thirties, including the competitive exclusion principle and the Lotka-Volterra predator-prey equations, further encouraged studies along these lines. (p. 9)

Today however, a new generation of ecologists and biologists have again begun to doubt the capacity of competition and predation to explain the distribution and abundance of living organisms. Doubt such as this stems from the fact that "...at this point in time the results of a great deal of theory and field and laboratory study on competition and predation have met with limited success in explaining community, stability, diversity, and succession" (Risch and Bourcher,1976, p.8). Furthermore, as Schmookler (1984) pointed out:

> The survival of life forms depends on their ability to integrate into an evolving environment. The main characteristic of their process is not competition between species, but is the ability of the organism to integrate or fit with a particular ecological niche. This would also be true for human society, even with our ability to modify our environment [and the role which we play within our community]. (p.10)

According to Boucher (1985), as early as 1902, Peter Kropotkin pointed out in his best selling book _Mutual Aid_, that competition between animals was not enough to explain the complexities of nature, especially the progress of organic life. Kropotkin showed how cooperation, as well as competitiveness, can help organisms to survive and reproduce. Mutualism seems to be more powerful in nature than biologists and ecologists once assumed.

Beginning with Van Beneden, Alfred Espinas, Roscoe Pound, Warming, and Peter Kropotkin and continuing in the works of Warder C. Allee, Steven Risch, Douglas Boucher, John Wiens, Joseph Jehl, etc. the concept of mutualism has become recognized as an important factor in the interaction in nature and in the determination of community structure. Mutualism has been proven, theoretically and empirically, to play a key role in "...determining the abundance and distribution of organisms" (Risch and Bourcher, 1976 p. 8) and in turn in the function and the balance of natural communities (Risch Bourcher, 1976, Starr and Taggart, 1984; Wiens, 1983, Jehl, 1984, Bourcher, 1985). Yet little attention has been given to mutualistic relationships among either living organisms or human communities in biology and ecology textbooks at both school and college level. It is my argument that mutualistic relationships are too important to be passed over either in secondary school education or at the college level.

Students receiving the theory of competition as the fundamental process of nature without equal emphasis on symbiosis and co-operation are getting only half the story. In the long run, these students become anthropocentric in their thinking, regardless of the ecological knowledge they might have learned in their classrooms. Competition alone will not bring solutions to, for example, the three most difficult problems life is facing: nuclear war, overpopulation, and the acceleration of ecological crises. If we fail to teach concepts of mutualistic relationships, efforts to solve ecological crises might be fruitless. Without understanding concepts such as mutualism, competition leads to excessively anthropocentric thought.

Mutualistic relationships have always existed in nature. Evidence for the idea of mutualism can be traced back at least as far as 1500 B.C. (Abmadjian and Paracer,1986). According to Bourche (1985), both Herodotus and Aristotle used mutualism as examples of nature's balance. For example, the bird that eats leeches from the mouth of a crocodile is cited by both of these ancient writers. Pliny pointed out how:

> ...friendships occur between peacocks and pigeons, turtle-doves and parrots, blackbirds and turtle-doves, the crow and the little heron in a joint enmity against the fox kind, and the goshawk and kite against the buzzard. Why, are there not signs of affection even in snakes, the most hostile kind of animals? We have mentioned the story that Arcady tells about the snake that saved his master's life and recognized him by his voice. (Cited in Bourche, 1985, p. 8)

The universe is full of perfect adaptations between different kinds of organisms fruitfully co-existing and aiding each other. Mycorrhiza in which a fungus and the young roots of nearly all vascular plants in forests and grasslands mutually interact is another example. Flowering plants and their pollinators and agents of seed dispersal, are also good examples of mutualistic interaction in natural communities. Even human beings, some critics argue, are mutualistic and altruistic by nature, but have been coerced into competition, aggressiveness, male domination, etc. by our anthropocentric attitudes and beliefs.

However, the questions now are: how can we begin, and what can we do, so that people realize that mutual cooperation between different kinds of organisms are just as important as competition in helping each other to survive. Our thinking must change. According to Zlotnik (1986) :

> The dangers we face arise from our own thinking, from our ideas of the 'enemy', our ideas of power, authority, and security, of knowledge and truth-and of ourselves. Our world is a dangerous place, and it will remain so until we change the ways we think about one another and our place on the earth. (1986, p. 35)

Thus, we should start by offering students alternative ideas.[1] As Suzuki says (1986) in his series "Planet For The Taking":

> ...if we are trained to believe that aggression and strife and competition for commodities and for power are what makes the world go around, then we will interpret the world that way. But if we shift our perspective a little, shift expectations, then sometimes it is possible to see the world differently. Sometimes it is even possible to see new things.

It follows that if we are taught, for example, that in nature there are other relationships besides competition, aggression, and predation for achieving stability and success, we

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[1]-We should show them that there might be other ways of seeing and understanding the relationships among living organisms in nature. We should start by offering students opportunities to think in alternative ways when they face, for example, the question of what desires and attitudes they ought to have with respect to the environment.

might develop different attitudes not only toward each other, but toward nonhuman organisms and indeed the whole of nature. Therefore, if our children are brought up in the spirit of respect toward different kinds of mutualistic relationships, they might then develop the qualities needed for world peace and ecological stability. [1]

Chapter one and chapter two have dealt with the following claims that have been asserted by numerous people interested in ecology: (1) the ecological crisis on the earth has increased to alarming proportions unmatched in human history; (2) this crisis is the result of attitudes about the natural world developed by Western post-Cartesian technological society; (3) attitudes such as these are known as anthropocentric (speciesism and resourcism); and (4) an anthropocentric viewpoint has dominated the biology education through textbooks being used in North America at least since 1900. Given the undesirability of this state of affairs, education must reassess the goals of science education in general and ecology education in particular.

In the following chapter I examine the literature which deals with the goals, content and instruction of ecology within biology education at the secondary school level.

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[1] -Teachers are not going to have difficulty in teaching children to make friends with their classmates, and the children will later extend these ideas into their streets and city environment, society, and the world. This is likely to happen simply because children are naturally able to establish bonds of friendship. And, who knows, our children (the future generation) might never stand against each other, or other living organisms. They might never try to misuse the natural resources, if the present schooling system and its philosophy emphasizes respect and friendship as a way of understanding ourselves, and the natural world.

CHAPTER THREE

GOALS, CONTENT AND INSTRUCTION IN ECOLOGY EDUCATION

In this chapter, I will review the literature related to the goals, content and methods of ecology education at the secondary school level. Underlying the choice of this literature is the view that social and cultural change is possible through education. Yet education is influenced by current cultural attitudes and values, which in their turn affect the goals and content of education. Schooling should aim to improve as well as to maintain society and threrefore, it should also aim at producing citizens who are capable of effecting these results

The Goals of Ecology Education

Because of the dearth of literature dealing with ecology (which is housed within biology education at the secondary school level), I have drawn on the literature of ecology and biology education as well as environmental education.

The Goals of Environmental Education Programs

I review the goals of environmental education programs because ecology is the backbone of of all Eco-Education programs and these, according to Swan's (1975; 1985b) description, include, outdoor,conservation, and environmental education programs[1].

In his extensive research aimed at identifying the purposes generally cited for teaching Eco-Education programs Swan (1985b) concludes that all goals of programs such as these are related to "understanding, appreciation, care, and use of the resources found on planet Earth". Hungerford, Peyton, & Wilke (1980) argue that the ultimate goal for environmental education should be: "to provide an education which results in

1- Environmental topics have been inserted into science curriculum in a variety of forms (Blum, 1981), especially in the field of biology, which is considered to be the content source for more than 90% of the curricula of environmental education programs (Children, 1984).

environmentally-affirmative citizenship" (p. 6). Specifically, however, the most commonly found goals of environmental education are: (a) to develop ecological knowledge and awareness; (b) to develop problem-solving and scientific inquiry skills (such as observation and identification, investigation and classification, clarification and interpretation, and reasoning and evaluation); and (c) to develop the motivation, abilities and dedication to act in ecologically and socially desirable ways, individually as well as collectively (e.g. Terry, 1971; Tanner, 1974; Swan and Stapp, 1974; McInnise, and Albrecht, 1975; Unep-The Belgrade Charter,1976; Harvey,1977; Herbert Lef, 1978; Hungerford, et al., 1980)[1]. In other words, the goals of environmental education are to develop environmentally literate citizens (Kupchell and Hyland, 1977) and to ensure that they become "a necessary prerequisite for effective participation in today's society" (Nash,1976, p.10)

The literature, however, clearly indicates that only the goals related to developing ecological knowledge and awareness have received adequate attention in the classroom. Indeed, a great gap between the environmental education goals and their achievement has been reported (Volk,1983; Volk, Hungerford, and Tomera,1984; Iouis, 1984). Many environmental educators argue that to be effective, environmental education should emphasize the understanding of how values and ethics enter into the problem-solving and decision-making process in a democratic society (Wright,1983). Goals related to investigation and evaluation of issues and solutions as well as citizenship action should also be emphasized, especially in the secondary schools and at college levels (Volk,1983; Volk, Hungerford, and Tomera, 1984). The development and implementation of goals such as these are urgently needed today which means that there is a still a need for goal-oriented curricula in environmental education.

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[1]- In order for these goals to be implemented in the environmental education curriculum, Hungerford, Peyton, and Wilk (1980) examine the existing goals and put them into a plan of four goal levels which are: (1)- Ecological Foundations; (2)- Conceptual Awareness and Human Values; (3)- Investigations, Evaluations, and Solutions; and (4)- Environmental Citizenship Participation and Action.

The goals of Biology Education

The justification for looking at the goals of biology education is that ecology is housed within biology curriculum in secondary school science education. After reviewing the current status of goals described in Project Synthesis, analyzing the goals of biology textbooks, and reviewing science related social issues, Hurd, Bybee, Kahle, and Yager (1980) proposed the following basic instructional statements for biology education:

1. Biology education should develop a fundamental understanding of biological systems.
2. Biology education should develop a fundamental understanding of, and ability to use the methods of scientific investigation.
3. Biology education should contribute to an understanding and fulfilment of personal needs and thus contribute to the development of individuals.
4. Biology education should inform students about careers in the biological sciences. (p. 390)

These basic statements of instruction reflect the five goals of biology education which are: biological knowledge, scientific methods, social issues, personal needs, and career preparation (Hurd, et, al., 1980) as stated in Project Synthesis[1],

Furthermore, the Science Council of Canada in its report No.36 *Science for Every Student* (1984) lists four main aims[2], which further translate into several goals in the British Columbia secondary school biology curriculum. These goals are:

1- Project Synthesis, which was funded by the National Science Foundation in 1978, examined the teaching of biology, the physical and earth sciences, inquiry, elementary school sciences, and science/technology/ society in order to determine the status of K-12 science education in the U.S. The project Synthesis staff identified and described the following four goal clusters; goals upon which numerous studies have been made:

I- Goal Cluster 1: Personal Needs. Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.

II- Goal Cluster 11: Social Needs. Science education should produce informed citizens prepared to deal responsibly with science related social issues.

III- Goal cluster 111; Academic Preparation. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

IV- Goal Clusters 1V: Career Education/Awareness. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests. (Kahle and Harms, 1981, p. 7-8)

2- The Science Council of Canada in its report 36 "Science for Every Student" (1984) states four main aims which enable students to 1. Participate fully in a technological society as informed citizens; 2. Pursue further studies in science and technology; 3. Enter the world of work; and 4. Develop intellectually and morally.

Goal A - Biology curriculum should provide opportunities for students to develop scientific attitudes, and to develop positive attitudes toward science.
Goal B -Biology curriculum should provide opportunities for students to acquire the skills and understand the processes of science.
Goal C -Biology curriculum should provide opportunities for students to increase their understanding of the basic concepts and principles of biological science.
Goal D -Biology curriculum should provide opportunities for students to develop critical and abstract thinking abilities.
(Biology 11 & 12 Curriculum Guide, 1986, p. 3)

If all the above mentioned goals for biology education are adequately implemented, they will be relevant not only to science teachers and science or biology students, but to the vast majority of future citizens, regardless of their ultimate careers, because they also reflect the calls for a new emphasis on bio-social and ecological goals in biology education. But the two questions that present themselves here are : (1) are the curriculum content, materials, textbooks and teaching aids demanded sufficient to achieve these goals? and (2) have biology teachers in B.C. received sufficient training to realize such aims? The conclusion to be drawn from the recent revision of secondary school biology curricula in British Columbia suggests that the answer to both questions is 'no', as we will see in chapter five and six of this thesis. For the moment, it is sufficient to restate what is clearly stated in the biology 11 & 12 curriculum guide of British Columbia, namely that many biology 11 & 12 learning results are specifically derived from the goals, or directed toward the goals, of scientific skills and processes (goal B), and knowledge (goal C), "but that some outcomes encourage the development of scientific attitudes and critical thinking abilities as well" (p.7). I find it hard to believe that the inculcation of scientific attitudes and critical thinking abilities among students can be guaranteed when the learning outcome is directed almost entirely toward developing scientific knowledge, skills and processes. Secondly, the goals of scientific skills and processes (goal B), and knowledge (goal C), are driven mostly by the core areas of the curricula.

Goals For Curriculum Development in Ecology Education

Studies dealing with ecology within biology education at the secondary school level are few. The need of our society for transition toward ecocentric orientation has been recognized by many (e.g Bennett, 1976). Some however, such as Perelman (1976), Bybee (1979a,1979b, 1979c, 1977a, 1977b,1984), Zverve (1982), Contreras Manfredi (1986), and Stoshkus (1987)[1], have gone even further by proposing that our need to achieve an ecological society might be possible through schooling.

Perelman (1976) suggests that the goal of ecology education is to develop an ecologically educated person, who in turn, is capable of creating an ecologically harmonious society. Bybee (1979a,1979b, 1979c, 1977a, 1977b,1984) argues that the goal of all science education (not just ecology education) should be devoted to developing a citizenry "whose decisions are personally informed, ecologically sound, ethically defensible and socially compatible" (1987c, p. 163)[2]. Such a citizenry, he believes, would be capable of creating an ecological society. Zverve (1982) argues that the goal of ecology in school education is to develop an ecologically "cultured" person who is, in turn, capable of creating an ecologically "cultured" society. He goes further to argue that school disciplines should be carefully ecologized and aimed toward a common objective of forming an "ecological culture in the younger generation" (p.17). I take "cultured" here to mean educated or highly sophisticated ecologically. Manfredi (1986) with the desire to emphasize the close relationship between ecological culture and quality of life, has developed an educational program which aims to stimulate the development and enrichment of an ecological, conservationist culture in Latin American communities. The main goal of an ecological culture such as this, he believes, is to seek to preserve a balance (between

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1- Stoshkus' (1987) article "Understanding the Ecological Culture of Society " was orally translated from Russian to the author of this thesis by Beata Giuffer, graduate student at the Faculty of Education, Simon Fraser University- Burnaby, B.C. Canada.

2- Paul Dehart Hurd also holds the view that science should be taught in ecological context specially those principles which have recognizable consequences for human biengs (Bybee, 1979a).

economy of energy, of nutrients, and biological capital) and to sustain products; these things are vital in the improvement and maintenance of a good quality of life and a healthy ecosystem. I will elaborate further on three of these four innovative theories.

Perelman (1976) proposes three kinds of goals for the transformation of the existing society: long-term equilibrium goals, mid-term system goals, and short-term educational goals. The purpose of long-term goals are to establish, develop and maintain a state of global equilibrium. He adds, "this is equivalent to the cultivation of ecological consciousness and the creation of a growing cadre of competent transformers" (p. 233). The purpose of the short-term goals is to generate the knowledge for application and the capable manpower necessary to arrive at this state of equilibrium. But "before a viable equilibrium society can be established, it will be necessary to establish a creative transformation society comprised of institutions which are themselves transformational in nature" (p. 212). The purpose of the mid-term goals is to create a climate for this transformational society

Like Perelman (1976), Zverve (1982) convincingly argues that the long-term goal of ecology education is to develop an ecologically cultured person who in turn is able to work with others to develop an ecologically cultured society. According to this goal, an ecologically cultured person has the following characteristics: (1) A person who is "aware of the general patterns in the development of nature and society, realizes that social history is a consequence of the history of nature, and that nature is the fundamental principle underlying the formation and existence of man"; (2) a person who "subordinates all types of activities to the demands of rational nature resource utilization is concerned with improving the environment, and does not permit its destruction and pollution"; (3) a person who is able to " master scientific knowledge, assimilate moral value orientations regarding nature, and acquire the practical skills needed to preserve favourable conditions in the environment" (Zverve, 1982, p. 7&8). All these characteristics, he believes, should ultimately lead to the development of an ecologically effective person and, in turn, an ecologically cultured society.

According to Zverve (1982), the main function of an ecological culture is to regulate humankind's attitudes toward his or her own future, the future of nature, and the resolution of contemporary and future global problems. Thus, he seems at least partially, in agreement with both Perelman (1976) and Bybee (1979a,1979b, 1979c) on the role of ecology in school education.

Bybee's work (1979a,1979b, 1979c, 1977a, 1977b,1984) provides a good foundation for educational thought and the policy of developing an ecological society through schooling. "Fulfilling basic human needs, decreasing environmental damage, conserving natural resources, and developing peace in the global community" (1989b,p.,254) are the central focus of his proposal. He argues, that the concern for scientists in the next decade will be that the three realms, science, ecology and ethics, be understood as interrelated and interdependent if humankind is to continue to survive and develop (p. 254).

Based on those previously mentioned goals for environmental, biology and ecology education, the literature seems to suggest that the long term goals of ecology education should be: (1) Developing an ecologically literate citizenry; (2) Developing a global ecological mind; and (3) Planting ecocentric attitudes in the minds of human beings where an anthropocentric philosophy is already deeply rooted. However, in school ecology, student educational progress cannot be easily evaluated. Thus, preliminary or leading goals (short-term goals) are needed to achieve the long term goals. In other words, unless we have preliminary or leading goals on which schooling can operate, the long term goals may never be achieved. However, all these goals have to be stated clearly so that curriculum planners and teachers can implement them within school education.

But, which of these goals can teachers actually use to teach ecology? Because of the dearth of literature on the topic, this question, while appropriate, is difficult to answer.

However, by relying on Perelman, (1976), Bybee (1979a; 1979b; 1984), Zverev (1982), Adams, Charles, Greene, and Swan (1985), and the major goals of various environmental, projects such as Project Learning Tree, Project Wild, The Class Project, etc.[1], the general purpose of teaching ecology in school education can be restated in this way:

I To develop breadth and depth of understanding of ecology, ecological systems, and issues;

II To develope the necessary motivation, skills, and abilities for solving the current global ecocrisis, and to prevent new ones; and

III To develope the know how and manpower necessary for the transformation from a state of ecocrisis to an ecologically sustainable society.

However, the literature claims that developing ecological knowledge and awareness rather than understanding and preparation for taking responsible action, remains the primary goal of school ecology. This suggests that the above cited literature does not discriminate between teaching ecology and biology and other eco-education programs, regardless of the fact that ecology differs radically, not only from the traditional instructional approach of school science, but also in its goals, structure and subject matter.

One vital question emerges from this section of the literature review: Is current school education really educating young citizens and planting the right seeds for ecocentric belief and an eco-technological society? If not, why have we failed to attain these goals? One might postulate many reasons, but I suggest three possibilities why these goals have not been achieved :

1- According to Adams, Charles, Greece & Swan (1985) the major goal of: The Project Learning Tree is "...to enable the student to develop awareness and understanding of environmental relationships and interactions using the forest and associated resources as the primary vehicle "(p. 464). The Project Wild is "... to assist learners of any age in developing awareness, knowledge, skills and commitment resulting in informed decisions, responsible behavior and constructive actions concerning wildlife and the environment upon which all life depends"(p. 465). The Class Project, which is designed to provide students with real experiences in solving ecosocial problems within their community, is "...to develop an environmental ethics and help them use their acquired skills and concepts in taking thoughtful, positive action that will protect and enhance the natural environment" (p. 467). In other words, the goal is to help students identify and solve social/ environmental problems.

1. These goals might not have been translated from recommendations in research literature into content in textbooks, because of the influence of special interest-groups or the economic motives behind textbook sales, or:

2. Even if those goals are already being introduced into school curriculum and their intended implementation, teachers might not be evaluating student progress towards these goals, but only their progress in learning the factual content component. If this is so, it might be because do not have the right training and education to teach goals such as citizenship action, personal and social needs, etc. The literature of ecology and biology education, as well as of environmental education programs, states clearly that such a goal as developing knowledge and awareness receives much emphasis among all the proposed goals in education (e.g., Volk, et,al.,1984; Harms and Kahle, 1981; Hurd, et,al,1980). Elkin (1977),[1] among others has argued that the development of rational beings and decision-makers requires ecological knowledge and awareness as well as the ability and dedication to behave and act ecologically. It is my belief that to expect people to behave in an ecologically responsible way, we must provide them with education and the necessary techniques for problem-solving, reasoning and thinking abilities, as well as action and value clarification skills.

3. The goals of education in a given society rest upon the role of education as defined by that society's members (particularly policy makers, educational philosophers, and curriculum developers). Part of the problem may be that North American society does not look at school as a key instrument for generating and developing the know-how and manpower necessary for solving social issues. Since social issues, citizenship action, personal and social needs, etc. do not gain much attention from taxpayers, they may be of

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[1]- Elkin (1977) argues in one of his remarkable works "The Individual and Environment", that " The key to environmental education, indeed all education, is in enabling individuals to learn why and how to act effectively on their environment and to select and manage the quality of their own experience; to enable them to determine for themselves what is "worth doing" and to develop a general understanding of the nature of doing, or actions, so that they will be able to carry out their intentions" (p. 274).

little concern to policy makers and curriculum planners specially whose who central preoccupation is employment. Accordingly, environmental questions to these people tend to be seen only in short-range economic terms. Since the success of any venture depends largely on the goals established in the beginning, and since the long term goals of ecology education are not stated clearly in the school curriculum, this lack of clarification is undoubtedly part of the problem.

In summary, the literature reviewed seems to suggest a widespread opinion to the effect that if we want to transform human society into an ecotechnologically aware and sustainable society, we need not only short-term goals, but also long-term goals. The teaching of ecology deals directly with preliminary goals and only indirectly with long-term goals, and therefore, must be modified. The short-term goals of developing ecological knowledge and awareness, and of understanding ecological systems, must be joined by an explicit goal of developing in students an ecological conscience and an ability to respond critically to ecological issues through approprate action. Only goals such as these can develop the values necessary to change our anthropocentric attitudes and behavior toward into an ecocentric world view.

The Content of Ecology In Biology Textbooks

In this section, I examine the literature which deals with the subject of ecology itself and also with its associated areas (e.g. evolution, energy, behavior) as found in biology textbooks at the secondary school level. In undertaking this examination, I adhere to the view that the proper goals of ecology education cannot be realized without a specific content by which students gain the knowledge necessary for developing responsible citizenship. The main task of this section,therefore, is to examine what the literature has said about the existing content of school ecology, and also about the content that should be provided. I deal both with studies covering many topics within the texts (e.g. Science Books and Films, 1985; Carrick, 1977, 1978, 1982; Rosenthal, 1984, 1985; Cho and Kahle, 1984; Stuart, 1982;), and those which are limited to only one topic within a given text (e.g. Skoog, 1969, 1979, 1984; Barber, 1982; Stone, 1984). I begin my review with the recent special issue of Science Books and Films (SB&F, 1985) devoted to biology textbooks, which according to Kathleen Johnston (1985), editor of Science Books and Films (SB&F), is the most comprehensive evaluation of pre-college biology texts undertaken in recent years.

Science Books and Films Study

Background

The American Association for the Advancement of Science through its publication Science Books & Films (SB&F) aims to give critical reviews of books, films, videocassettes, and filmstrips in science education. In 1985, SB&F studied 35 biology textbooks and supplemental materials (including teachers' guides and lab manuals) frequently used, or expected to be used, in junior high school, and senior high school introductory and advanced biology classes in the entire United States[1]. My reasons for evaluating this study are that it is the most comprehensive recent study available of high school texts in the field and, it has the largest number of biology textbooks ever evaluated. However, the study did not summarize the results, nor did it draw any conclusions or find relationships between the 35 textbooks[2]. By reading and examining everything that the SB&F evaluators (teachers, science educators, and biologists) wrote about those 35 texts, I

1- However, SB&F states clearly that it examined only those texts whose authors chose to send to SB&F requests for review.

2- In fact SB&F specifically resisted doing this; as Johnston (1985) states:"That is not to say that through our evaluation we intend to make any statement about the wisdom or not of the way biology fits into most middle and secondary school curricula. Individual reviewers did make remarks about the issue, and we let them stand as the opinions of those individuals. Some reviewers also made comments on what science education in general should and should not be, although our effort is not meant to address that issue directly." (p. 244) endeavored to find what relationships and conclusions could be derived about ecology and its associated areas in biology textbooks.

The SB&F felt that good science textbooks should elucidate the nature of science and supply adequate scientific content. They should lead students to understand the degree of credibility that can be placed in scientific data compared to assertions based on their world view, and be pedagogically sound. Because of this

> [e]ach text [of the 35] was matched to a set of three reviewers from different regions of the country [USA]...Each set of reviews included a current or former middle or secondary school biology teacher a science educator (someone who does research in science education), and a biologist. The criteria they used were the criteria SB&F uses for review of supplemental science and math books....The specific criteria [used by the evaluators] included level of difficulty (appropriate grade level and orientation of student) and content-objectivity, accuracy, currency. Each reviewer also commented on the development (organization) and illustrations,...other criteria used included: how well the text presents scientific methods and processes; how well it relates to the world of the student motivation; and how well it deals with inquiry of four separate levels. Other concerns were also covered, including appropriateness of vocabulary and adequacy of chapter summaries. (Johnston, 1985, p. 244)

The three main categories of the SB&F study were thus, content, organization, and pedagogy. However, at this point I am concerned only with content.[1]

The results of the SB&F evaluations were represented in two ways. First, two separate tables for each grade level (general content table and specific content table) contain the summary of the evaluation of each text separately, and represent the evaluation of each interviewer independently. Second, for each text, three separate paragraphs were written; each by a different evaluator.

<u>Conclusions From The SB&F Study of Biology Textbooks</u>

My conclusions from the SB&F study are divided into two categories: (a) General Conclusions, and (b) Specific Conclusions. In the former, I examine what the SB&F

[1]- In examining the content of the texts, ten key conceptual areas of biological science were used by the SB&F study to rate the quality of the text's content coverage. These conceptual areas, which for my purpose make this study worth examining, include ecology and associated subjects such as evolution, behavior, energy transformation, etc.

study says about the content of ecology and associated subjects and which underlying themes imply an ecological approach. In the latter, I examine what the study says about the two commonly used high school biology textbooks identified by Weiss (1978). The results of the other related studies follow with both general and specific conclusions.

General Conclusions

Ecology: As shown in table (3.1), all the evaluators in the SB&F study agreed that ecology in most biology textbooks (n=35) in use in introductory and advanced biology classes throughout the United States is adequately dealt with. Only a small fraction of the evaluated texts were considered poor in their coverage of ecology.

Table 3.1
The status of ecology content in 35 biology textbooks evaluated by SB&F (1985)

The Status of Ecology Content							
Evaluator	Poor	Fair	Adequate	Good	Excellent	No Answer	Total
Teacher	4	3	10	8	9	1	35
Biologist	3	6	12	5	9	-	35
Sc. Educator	2	3	8	15	7	-	35

Specifically, regarding ecology, teachers believe 10 of all texts (n=35) are adequate, 8 are good, and 9 are excellent. Only 7 texts are poor and/or fair in their coverage of ecology content. Science educators are more optimistic than teachers and biologists. They believe that 15 of the texts are good, 8 are adequate, 7 are excellent, and only 5 are poor and/or fair regarding ecology. Biologists believe that 12 of those texts which teachers and educators evaluated, are adequate, 9 are excellent, and only 5 are good. They also evaluated 9 other texts as poor and/or fair in their treatment of ecology.

Ecologically associated subjects: Because their underlying themes imply an ecological approach, energy transformation, evolution, and behavior have been considered to be areas associated with ecology. These topics enhance the understanding of the interrelationships between organisms and their environments, and therefore have been included with ecology in this literature review. As shown in table 3.2, 3.3, and 3.4, most of the evaluated textbooks were rated adequate, good, or excellent in their coverage of energy transformation[1], evolution[2] and behavior[3].

Table 3.2
The status of energy content in 35 biology textbooks evaluated by SB&F (1985)

The Status of Energy Content							
Evaluator	Poor	Fair	Adequate	Good	Excellent	No Answer	Total
Teacher	4	3	14	9	4	1	35
Biologist	1	9	6	10	8	1	35
Educator	4	5	12	4	10	-	35

Table 3.3
The status of behavior content in 35 biology textbooks evaluated by SB&F (1985)

The Status of Behavior Content							
Evaluator	Poor	Fair	Adequate	Good	Excellent	No Answer	Total
Teacher	6	12	6	8	2	1	35
Biologist	4	11	9	7	3	1	35
Educator	9	5	6	10	5	-	35

Table 3.4
The status of evolution content in 35 biology textbooks evaluated by by SB&F (1985)

The Status of Evolution Content							
Evaluator	Poor	Fair	Adequate	Good	Excellent	No Answer	Total
Teacher	5	5	8	10	7	1	35
Biologist	8	2	6 —	11	8	-	35
Educators	5	5	8	13	4	-	35

1- As shown in table (3.2), teachers evaluated 14 texts as adequate, 13 texts as good and/or excellent, and only 7 others as poor and/or fair in their treatment of energy. Science educators thought 12 text were adequate, 14 were good and/or excellent in their treatment of energy, but 9 other texts were poor and/or fair.. Biologists evaluated half of the texts (18) as good and/or excellent, 10 others were considered only as poor and/or fair.

2- Evolution: As shown in the table (3.4), all the evaluators agreed that 10 of the 35 texts were poor and/or fair in their treatment of the concept of evolution. On the other hand they also agreed that almost half of the texts were good and/or excellent in their treatment of evolution.

3- As shown in table (3.3), educators thought 15 texts were good and/or excellent and 14 others were poor and/or fair in their treatment of behavior content. Both teachers and biologist evaluated 10 texts as good and/or excellent. However, teachers thought half of the texts (18/35) were poor and/or fair in behavior content, and biologist thought 15 were poor and/or fair in this matter.

Only four textbooks received unanimous evaluation. As shown in table (3.5) only two texts all the evaluators considered good and only two others were considered excellent in ecology.

Table 3.5
The number of specific textbooks that all the evaluators agreed were either poor, fair, adequate, good, or excellent of 35 biology textbooks evaluated by SB&F (1985).

	Poor	Fair	Adequate	Good	Excellent	Total
Ecology	1	-	1	2	2	6
Energy	-	-	1	1	1	3
Evolution	1	-	1	1	-	3
Behavior	1	1	-	2	-	4

Specific Conclusions

In this section, I examine what the literature has concluded about specific biology textbooks: Biological Science: An Ecological Approach, (BSCS - Green version) and Macmillan Biology. The former text used in two thirds of biology classes in North America (Weiss,1978), has been identified as one of the three most popular biology textbooks. It also rates among the four most popular textbooks for ecology, (Barber, 1982). It was in use in British Columbia biology classrooms up to 1985. The latter text (Macmillan Biology) was chosen as one of the two new biology textbooks for secondary school biology classrooms in British Columbia. I look at these two texts specifically within the results of the SB&F study (1985), Rosenthal (1984; 1985), and other related studies (i.e.Bybee, 1979c; Stone, 1984; 1985; Igelsrud & Leonard, 1988).

As shown in table (3.6), all the evaluators agreed that the BSCS-Green Version is excellent and/or good in its coverage of ecology, evolution and behavior. While teachers rated the BSCS-Green Version as only adequate, both biologists and science educators thought it excellent in its coverage of energy transformation. The evaluators, however, rated the *Macmillan Biology* textbook variously with no agreement on the quality of its coverage of any evaluated topics.[1]

Table 3.6
The status of ecology and its associated themes in two most used biology textbooks: BSCS-Green Version and Macmillan Biology

	BSCS - Green Version			Macmillan Biology		
Themes	Teachers	Biologists	Educators	Teachers	Biologists	Educators
Ecology	Excellent	Excellent	Excellent	Excellent	Fair	Adequate
Energy	Adequate	Excellent	Excellent	Excellent	Adequate	Good
Evolution	Excellent	Excellent	Good	Excellent	poor	Good
Behavior	Good	Good	Good	Fair	Fair	Adequate

Many other research studies agreed with the SB&F result regarding Biological Science: An Ecological Approach (BSCS Green Version (e.g. Tamir and Jungwirth, 1975; Bybee, 1979c; Stone, 1984; 1985; Shymansky, 1984; Igelsrud & Leonard, 1987). The reason for this agreement seems to be because BSCS Green Version was developed through the cooperation of scientists, educators and science teachers. In addition:

> The curricular products of the BSCS movement beginning in the early 1960s have undergone extensive evaluation, both short and long term, comparing them to the existing, traditional programs. Although many of the single studies are inconclusive, very few favor the traditional programs. Many favor the BSCS programs for producing greater student learning of biological information, more extensive development of science process skills and more positive attitudes toward science...A recent and extensive meta-analysis [Shymansky,1984) indicates that the long term effects of the process-oriented biology programs developed by BSCS were measurably superior to those of traditional curricula in student understanding of biological concepts and scientific thinking skills. (Igelsrud & Leonard, 1987, p. 304)

1- The teachers in the SB&F study evaluated the two texts (BSCS-Green Version and Macmillan Biology) as good and/or excellent in their treatment of ecology and its associated subjects with an exception the behavior content in Macmillan Biology and energy content in BSCS. Science educators evaluated the BSCS-Green Version as good and/or excellent in its treatment of ecology and associated subjects. But they evaluated Macmillan Biology as good in energy and evolution and only adequate in both ecology and behavior. Biologists on the other hand, while they thought the BSCS-Green Version was good and/or excellent in ecology and associated subjects, evaluated Macmillan Biology text as only adequate in the energy subject, fair in both ecology and behavior, and poor in evolution content. Generally, then it is clear from table (3.6) that all the evaluators in the SB&F study are agreement that BSCS-Green Version is a better text.

Furthermore, Rosenthal (1985) found while BSCS "...gives the greatest sense of global perspective, both in the number of issues treated as global matters and in the length and depth of the treatments" (p. 461), the earlier editions, give more space, and a more sophisticated treatment to global issues than do the later ones. But Rosenthal (1985) also found that the *Macmillan Biology* textbook of 1981 "gives some attention to the global aspects of population growth, food supply, disease and use of resources" (p.461).

Related Studies

Optimistic results regarding ecology are found in Stuart's (1982) survey of the content of fifteen biology textbooks used in junior (seven texts) and senior (eight texts) high school. Stuart (1982) found that the presentation of ecology in biology textbooks is improving. Specifically, he noticed that 28% of the texts' concepts were ecologically related. Cho and Kahle (1984) seem to agree regarding the enduring popularity of ecology in biology textbooks in a ten year period (1973-1983) in comparison to other biological concepts.

The Illinois biology teachers surveyed in Barber's (1982) study also felt that the textbooks they use, "included important ecological concepts and gave appropriate emphasis to ecology with respect to the emphasis given other content areas" (p, 148). However, Barber (1982) noticed a discrepancy between what biology teachers feel and what researchers in the field identified in terms of applying ecological concepts to environmental problems in biology textbooks.[1]

By now, it should be evident that the SB&F (1985) study, Stuart's (1982) study, and the Illinois biology teachers in Barber's (1982) study are optimistic about the inclusion of ecology in biology textbooks. Their findings can be interpreted as suggesting that the publishers of biology textbooks are responding to the numerous calls for making science

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[1]- While the Illinois biology teachers believe that their textbooks did apply adequate ecological concepts to environmental problems studied in the classroom, several educational researchers suggested otherwise (e.g. Bybee, 1979c; Levin and Lindbeck, 1979, Barber, 1982).

relevant to the students (e.g., Harms and Yager, 1981) and for the need to teach ecological and environmental topics in secondary schools. Thus, in general, the content of ecology within secondary school biology textbooks has increased over recent years. Indeed, according to the SB&F study (1985), biology textbooks are adequately dealing with ecology at the secondary school level. However, other research studies indicate otherwise.

Carol Stone (1984;1985) who examined biology and history textbooks in an attempt to find out if they reflect environmental concerns in North America (mainly the U.S.A) noticed a decline in the number of pages that contained environmental topics in high school biology textbooks. She wrote that :

> In Hunter's 1914 Book, 64 percent of the pages had contained some "environmental" topics, such as predation or photosynthesis (Here, "environmental" topics are those showing any interaction between organisms and their surroundings) And, environmental topics were found on 51 percent of Kinsey's pages (1933;1938). But the 1968 Green Version (by Haven Kolb and others) contained such topics on only 41 percent of its pages....And in 1968, other textbooks contained even smaller percentages of environmental topics. (p., 86)

One of the remarkable studies which relates to the ecology content in high school biology courses was done by Barber in 1982. According to this study, one can find several criticisms about how high school biology textbooks represent ecology. Such criticisms include (a) lack of the application of ecological principles and concepts to environmental problems (e.g., Barber, 1982); (b) lack of emphasis on the importance of social problems as well as ethical issues (e.g., Bybee, 1979c); and (c) the misleading manner of presenting ecologically related problems (e.g., Barber, 1982; Tanner, 1980). The situation becomes more questionable if we consider the views of both Tanner (1980) and Mclnerney (1986). Tanner (1980) wrote that :"...traditional school texts had taught ...that we were safe in the hands of "Big Brother" ; government resource agencies had largely solved our environmental problems and were now steadfastly protecting our resources for generations to come" (p. 141; cited in Barber, 1982, p.61).

And McInernce (1986) discovered that:

> If one examines the 30-plus textbooks currently available for high school biology, one finds little diversity in the way the discipline is presented to students, in the instructional strategies, or in the demands the materials make on students- -or on teachers, for that matter. (p. 396)

These findings may be why many curriculum supervisors hold the attitude that all textbooks are alike, and thus they patronize publishers who give them a better package deal. However, this kind of criticism takes on a new dimension when we consider that school curriculum seems to have been designed to protect students from learning about themselves and other people (Arnsdorf 1972); that the human being has been hidden from the students in biology curriculum (Hurd, 1971); and that ecology has been taught primarily as the interrelationship of non-human organisms with their surroundings without due consideration of human beings as members of an ecosystem (Arnsdorf, 1972; Studebaker, 1973). Biology curricula have not yet provided an accurate view of world problems, the knowledge of which many researchers (e.g., Bybee, 1979c) see as essential to our continued survival and welfare. In other words, biological knowledge and social issues have not been related to the real life of students in the biology classroom (Harms and Yager, 1981). Young people who have not been taught to see themselves as vital organisms in a complex interdependent environment can quite easily leave decisions (in which they as the inheritors of the ecosystem have a profound interest) to "Big Brother".

Two remarkable studies of high school biology textbooks were done by Dorothy Rosenthal (1984; 1985) who analyzed 22 textbooks (using content analysis) for their treatment of social and global issues respectively. In those studies, she found that high school biology textbooks published between 1963 and 1983 paid less attention to social issues and the social aspect of science as time progressed. Specifically, Rosenthal found that space research, human behavior, population, nature of science, and environmental issues received the lowest attention among all 12 identified categories. Rosenthal concluded that regardless of the call for greater emphasis on science and society in high school biology education in the 1980's, the concern about technology and economics seemed to be the current emphasis, at least in those biology texts which she analyzed.

Rosenthal is well aware of the impact of social issues on human life, not only regionally and nationally, but also internationally, and globally. She believes that:

> Global dimensions would seem to be a natural aspect of biology education because biology has taught us much about the unity of life. From the study of evolution , we learn that all living things originated from a few primitive life forms. From genetics, we learn that the genetic code is universal for terrestrial life forms. From biochemistry, we learn that the basic mechanisms of life are very similar in seemingly diverse life forms. Finally, from energy, we learn that we are all part of an interrelated web of life on the spaceship earth.(1985, p. 459)

When she studied the global issues in 22 high school biology textbooks published between 1963-1983 she found that there was an unfortunate lack of global perspective in the treatment of social issues, and concluded that in general "...the treatment of science and society in high school biology textbooks minimizes the controversial aspects, avoids questions of ethics and values, lacks a global perspective, and neglects the interdisciplinary nature of problems"(1984,p. 829). In 1984, Cho and Kahle, who examined the impact of a national project's recommendations on biology textbook content in a ten year period (1973-1983) as well as the relationship between concept emphasis in high school biology texts and achievement level, found that, in general, the authors of the newer textbooks did not respond to the recommendations of the biology projects, something which Rosenthal's studies seem to support .

To conclude, therefore, while the SB&F (1985), Stuart (1982), and Cho and Kahle (1984) studies seem to be optimistic about ecology in school biology, all other studies mentioned seem to suggest the need for ecological improvement in the biology curriculum.

<u>Critical evaluation of this section of the literature review</u>

In evaluating this section, it seems evident that the SB&F study is fairly optimistic in terms of ecology,as are findings of Cho and Kahle (1984), who showed that ecology has gained popularity during the last ten years in high school biology textbooks, and the finding of Stuart (1982) that the presentation of ecology in biology textbooks is improving. However, one should keep in mind that Cho and Kahle's study was the one from which the SB&F study generated its ten conceptual areas of biological science. A problem presents itself, however, in that the SB&F study does not explain what 'excellent','good', 'adequate', and 'poor' specifically mean, and therefore, various people may judge differently. Also, the study does not give us facts about the amount and percentage of textual space devoted to each one of the ten conceptual areas of biological science, as well as what these ten conceptual areas contain, or include, in terms of subject matter. We must also consider that the amount and percentage of ecological content in the text might not be a valid indicator of the effectiveness of the teaching and/or the amount of time spent on it in the classroom.

Rosenthal (1984, 1985) disagrees with many of the above findings. Her studies are particularly pertinent to this thesis because her ideas concentrate around the following:

(1) The social and global categories can be considered ecological subjects and/or associated areas because the underlying ideas imply an ecological approach, and because these social and global issues are important in enhancing an accurate understanding of the relationships between organisms and their environments.

(2) Rosenthal's studies seem to agree with Dede and Hardin (1973); Hurd, Bybee, Kahle, and Yager (1980); Bybee (1979c); and Kieffer (1979) regarding the treatment of social and ethical issues in biology textbooks, especially the BSCS texts. Dede and Hardin (1973) for example, state that the BSCS of the Curriculum Reform Movement of the early 1960`s has been accused of paying too little attention to interdisciplinary and transdisciplinary matters. Hurd, Bybee, Kahle, and Yager (1980) feel that biological science curricula, which is supposed to address human and societal needs, as well as global and environmental problems, gives inadequate emphasis to these important issues. Bybee (1979) found that even though some biology textbooks do have sections on contemporary

social, and environmental problems, these sections either "avoid treating the issues as related to personal decisions of social actions", or "the importance of social problems is not emphasized nor are the ethical issues outlined" (p. 156). The ethical implications of biological problems and discoveries in terms of social issues and decision-making has gained little comprehensive recognition in biology textbooks (Kieffer, 1979; Bybee, 1979; Rosenthal,1984). Perhaps, because of these, most student's images of contemporary problems and associated social and human issues related to science and technology are believed to be formed as a product of out-of-school science experience, indirectly from sources such as television, or at best, through elective courses (Bybee,1979; Rakow, Welch, and Hueftle,1984). This has happened regardless of the findings that biology teachers, biology students, and public school administrators prefer to see goals related to social and environmental issues (such as making responsible decisions related to science, technology and environmental problems) placed ahead of a career orientation in biology instructional goals (Bedwell, 1984).

(3) Textbook authors/ publishers have not responded to the numerous requests from scientists and science educators for emphasis on social issues in school curricula, and it is less likely that they will respond to this demand in coming years; something which has already been emphasized by Project Synthesis (1978), and others such as Cho and Kahle (1984) and Mclnerney (1986).

(4) Biology textbooks have changed over the past few years, but in what direction? Mclnerney (1986) wrote in his article "Biology Textbooks _ Whose Business? that

> [It] would not be all bad if the convergence had been toward excellence, toward a representation of biology that has a solid conceptual framework; toward teaching strategies that promote inquiry and thinking, toward materials that incorporate the best new knowledge in cognitive science, toward a consensus on what constitutes useful, worthwhile knowledge; toward instruction that presents biology in relationship to other sciences and in relationship to the way modern science is done (Hurd, 1986); and, last, toward content that prepares students for their roles as citizens who will live the majority of their lives in the next century. (p. 397)

He adds that, researchers unfortunately suggest that :

> ...the convergence has instead been toward mediocrity; toward pedestrian representations of biology that are guaranteed to offend no one...; toward low-level intellectual skills; toward ever more information for its own sake; toward unquestioning adherence to questionable readability formulas...; and toward content that has little relevance to individual or societal concerns....(p. 397)

In conclusion, whereas on the one hand, the SB&F study sees that ecology is adequately dealt with in the 35 most popular high school biology textbooks, on the other hand this optimism is unmatched by most of the other citied studies. Exceptions are Stuart (1982) who claims that the concept of ecology in biology textbooks is improving and Cho and Kahle (1984) who state that ecology gained an enduring popularity during the last ten years or so in high school biology textbooks. Yet even the latter statement does not mean that ecology is adequately dealt with[1]. Nor are the three highly used biology textbooks identified by Weiss (1978) exceptions. For example, Biological science : An ecological approach (Green Version) is considered one of the best biology textbooks by the SB&F (1985) evaluators and stands above other textbooks in terms of both the quantity and quality of its treatment of social issues (Rosenthal,1984), but other sources indicate the opposite, that it lacks an adequate treatment of social, global, and moral and ethical issues (e.g., Hurd, et al., 1980; Bybee, 1979; Kieffer, 1977; Ded and Hardin 1973). It has also been criticized for paying little attention to interdisciplinary and transdisciplinary matters (Ded and Hardin, 1973). Moreover, Stone (1985) has noticed a slight decline in the number of pages that contain environmental topics in high school biology textbooks, including the Green Version (1968).

With all of the above in mind we should also consider the following :

1). Ecocrises and environmental problems are increasing at an alarming rate.

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[1]- Blum (1979) and Towler (1980-1981) notice that environmental topics, projects, and programs have increased in school curricula but observation such as this does not have anything to do with the ecological content existing within school biology courses.

2). Ecology, environment, or conservation topics are not likely to be taught as separate disciplines, nor is the degree of ecological education available to teachers in pre-service education, likely to increase now or in the near future (Towler, 1980-1981). And, where ecology is being taught, it is all too often regarded "as a separate and specialist area of knowledge, divided further into discrete component parts, such as plant and animal ecology, instead of recognizing the interdependences and interactions of ecosystems" (Hale, 1986b, p. 180).

3). Ecology, environmental, and conservation projects (e.g. Project Learning Tree; Project Wild; Class Project;) though readily available, are not compulsory projects even within school biology; and therefore, their implementations at the high school level are not widespread.

4). There is a strong indication from the literature that the quantity and quality of ecology content in biology courses is not sufficient to produce a productive, protective, and responsible citizenry necessary for a state of ecological equilibrium.

5). Bedwell (1984) found that social and environmental goals came in fourth place among five major goals of biology instruction by biology teachers and students as well as public school administrators.

Therefore, there is a gap between what those educators want and what they are getting. And since I agree with what they want to take place in ecology education, I claim that there is much need of improvement in the ecological content of high school biology textbooks. Furthermore, the tendency of high school students to develop broad ethical concerns and ecological appreciation of living animals and the rest of the natural world (Kellert, 1985) should be nurtured and not ignored. To clarify my findings in the above review of literature, I would now like to include a brief look at a study of biology in secondary school education in England.

Carrick (1977;1978; 1982) examined several textbooks for UK secondary school biology courses. Carrick surveyed 9 texts published between 1972-1976 and 11 texts published between 1976-1982. He studied the aims expressed by the author of each text, and analyzed the content on the basis of the attention given to the different levels of biological organization identified by the Biological Science Curriculum in the USA.Carrick also analyzed certain general characteristics, such as readability and use of questions in each textbook. Seven levels of organization were used in analyzing the content. As described by Carrick, these were:

> 1-Molecular level (m): molecular biology; chemical detail, including nutrition.
> 2-Cellular level (Cell): cellular and subcellular structure; cell division; cytoplasmic behavior as in streaming and plasmolysis.
> 3-Tissue and organ level (T): structure and activity of tissues, organs, and systems; plant and animal reproduction when referring to organs involved; glandular secretions.
> 4-Level of organism as an individual (I): description and morphology of whole organisms; characteristics of living things; life history; growth.
> 5-Population level (P): population size; effects of population pressure; birth control; population and classical genetics; process of evolution.
> 6-Community level (Comm): soil; ecosystems; parasitism and other interrelationships; disease when involving interrelationships.
> 7-Level of the world biome (W.B.): biogeography; global effects; origin of organisms. (Carrick, 1977, p. 164).

These seven levels were broken down into several topics and then each text was analyzed to see how each topic was covered. Was it illustrated, or mentioned very briefly or not covered at all ?

In general, the two studies of Carrick (1977;1982) indicate that none of the textbooks for UK secondary school biology courses published between 1972-1977 and 1978-1982 pay any attention to the world biome (global biology)[1]. A close analysis of Carrick's three studies, reveals the following more detailed conclusion. Soils, food chain and web , and carbon cycle are well covered (90.55%, 100%, 100% respectively) in texts

[1]- Carrick (1982) wrote that " Although population as such is discussed in most of the textbooks the overall attention to population level of organization seems less whereas aspects of the study of the biological community tend to occupy a slightly higher proportion of the books than previously [those published between 1972-1976] "(p.255).

published between 1979-1982. Energy flow is well covered in only 55.55% of the texts published during the same period(79-82). Surprisingly, 63.64% of the texts published between 1979-1982 mentioned the water cycle only briefly or not at all despite the importance of water for daily life, and the growing public concern in England over water pollution.

Critical examination of the 20 textbooks found the following topics to be well covered in the following percentages of the texts: adaptation to the environment (63.16%); nitrogen cycle (89.47%); population (78.95%); evolution, variation, and natural selection (79.95%); evolution in action at present (73.68%), and; classification (84.21%). On the other hand, 68.42% of all texts (N= 20) either mentioned only briefly or did not touch the topic of succession at all. Conservation.was poorly covered in 52.63% of all the texts. The scientific method, sampling and surveying respectively, were either mentioned very briefly or not covered at all in 63.16% and 68.42% of all the texts.

Because of critical studies such as Carrick's, the General Certificate of Secondary Education (GCSE) in England is experiencing a radical change (both quantitative and qualitative) in emphasis within the biology curriculum, particularly in regard to ecology. According to Carrick (1985), by 1988 the relationship between organisms with their environment will occupy between 25 and 40 percent of the total biology courses. This will occupy at least "one-and-a-half terms of a two year GCSE course" (p. 101) which will definitely require from teachers a major change in their in-service education[1]. What is interesting here is that ecological and environmental topics will become the first priority in biology education side-by-side with the themes of organization and maintenance of the individual. Traditionally, the latter, according to Carrick (1985), "has been given more attention than other parts of the syllabus" (p. 101).

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[1]- Here, I should mention that in the United States, Bybee (1984) suggests that human ecology should be included 25% of the time in biology class in high school. This means, " about one nine-week unit, one class a week or 15 minutes a day (60-minute classes). Emphasis should be toward the student as a concerned citizen" (Bybee, 1984. p. 20).

The four main themes suggested for GCSE are shown in table (3.7).

Table (3.7)

The four main biological themes suggested for GCSE

Themes	Topics	Percentage
Theme 1	Diversity of organisms	Between 5 and 10 percent
Theme 2	Relationship between organisms and their environment.	Between 25 and 40 percent
Theme 3	Organisms and maintenance of the individual.	Between 25 and 40 percent
Theme 4	Development of organism and the continuity of life	Between 15 and 25 percent

The topics listed under the relationship between organisms and their environment according to Carrick (1985) are :

> Energy flow within ecosystems
> Cycles of matter illustrated by carbon, nitrogen, and water, including reference to saprophytes as agents of decay
> Human interactions with environment; conservation, recycling, and pollution
> Population size; competition and control
> Parasites as pathogens. (Carrick, 1985b, 101)

It is clear from this list that more than just traditional ecology topics are planned for the future curriculum, many of them require an approach consistent with ecology in their teaching. Nevertheless, Croft (1986) argues that the National Criteria for Biology has failed to recognize the importance of developing skills through field observation and investigation of living organisms as being equally important in developing an awareness of the interrelationships of organisms with their environment. Instead, the emphasis is on developing an awareness of the relationships between organisms and their environment which can be interpreted through practical studies of a broad range of organisms. Croft (1986) found it difficult to comprehend the fact that the biologists who developed the National Criteria for Biology Education missed the point that investigating living organisms in a simple, accessible ecosystem is necessary for developing an accurate understanding and appreciation of the environment. Further critisim for biology education came from

Evans (1988) who believes that the A-level Biology Syllabuses of England " give insufficient attention to [hu]man's role in ecological processes and his interaction with the environment" (p.,136). He suggests that they should: "(a) place more emphsis on man's management of the environment; (b) consider environmental problems from a global perspective; and(c) approach many environmental issues from multi-disciplinary viewpoints" (p. 136). Cade (1988) holds different concern about the GCSC Biology in British education. He feels that the re-emerging age of 'relevant' biology should see an end to textbooks which give only a token last chapter to pollution, conservation, and ecology and should instead integrate the environmental context across the whole curriculum. He stated that it is the shift towards "affective rather than cognitive learning" in GCSC Biology which has allowed environmental context to illuminate the whole new biology curriculum (p. 159).

While I agree with Croft's (1986) and Evans's (1988) criticisms of biology syllabuses for GCSE, I see both these criticisms and the findings of Carrick (1977; 1978; 1982) on biology textbooks as support for what I have already stated: there is still a need for ecological content within biology education.

Concerned educators and scientists have been calling for more eco-education programs since the early 1970's. Curriculum designers and teachers have been slow to respond to these calls. What is needed is the implementation of more ecology, and themes associated with ecology, into school curricula, specifically biology. In addition, more scientific, ecological, social, political, economic, and global aspects of environmental considerations should be introduced to 12 to 18 year olds. Moreover, a need also exists for applying ecological knowledge in the discussion of environmental problems in biology textbooks (cf. Barber, 1982).

The Instruction of Ecology Education

In this section, I examine how biology has been taught at the secondary school level during the past twenty years. This is important since ecology at the secondary level is found almost exclusively within biology courses, and many believe that teaching ecology requires different instructional approaches from those customarily used in the biology classroom (e.g., Barber, 1982; Doweswell, 1979, Harms & Yager, 1981). I then examine how ecology and environmental topics have been taught, and discuss what the literature says about the difficulties teachers face in teaching ecology. Finally, I examine what the literature proposes instructional methods should be for teaching ecology and environmental topics.

How Has Biology Been Taught?

The literature has indicated that expository techniques (such as lecture, advance organizer, operant conditioning models of teaching, etc, which reflect a highly structured environment) are still the popular teaching approaches among many biology teachers at the secondary school level. Teaching has not changed much over the years (Costenson and Lawson, 1986). Even the influence of the 1950's which saw a strong call for change in science teaching to focus on scientific inquiry, problem-solving discussion and group investigation methods, and reasoning ability had little effect.[1] Teachers lecture more than 75% of the time (Hurd, et al., 1980), follow the traditional expository sequence consisting of the assignment, the test, discussion of the test (e.g., Barber, 1982; Harms & Yager, 1981; Kakle et al., 1979) and later retest to see whether the information is still in storage (Perelman, 1976; Hurd, et.al., 1980; Costenson and Lawson, 1986). These teaching

[1]- These methods were believed to lead to better performance when the understanding of concepts required both concrete and formal operational thought. This is important since many "...major concepts including evolution, genetics and ecology, taught in high school biology require formal operational thought [the ability to comprehend abstract ideas] to understand" (Igelsrud & Leonard, 1988, p. 304). While learning biology can be best achieved by first-hand investigation and discovery side-by-side with the content of scientific claims or explanation (e.g., Schwab, 1982; Lott, 1983; Shymansky,1984; Costenson; Lawson,1986; Lawson, 1988).

models reflect a highly structured environment and clearly emphasize the teacher's own choices in making instructional decisions (Jones, Thompson, & Miller, 1980).

Extensive use of expository teaching explains the findings of many researchers that students spend at least 70 - 95 % of their time in classrooms working with text materials (Mclnerney, 1986; Muther, 1985) and that most science teachers use textbooks as the primary instructional resource in the classroom (Barber, 1985; Harms & Yager,1981, Science Council of Canada, 1984). Field work, laboratory activities, scientific inquiry, and problem-solving and discussion methods which imply a significant amount of student decision-making and the application of biological knowledge to environmental problems, are not used in the classroom.[1] Therefore, as Hill (1986) concludes, biology teaching "...has not yet taken a sufficient account of either the practice of science or of the modern philosophical analysis of science and so has not yet succeeded in reflecting biological reality" (p. 12).

How Have Ecology and Environmental Topics Been Taught?

The literature suggests that current ecology teaching is similar to biology teaching, in which the expository technique is the norm. For example, Bottinelli (1979) found in Colorado, U.S.A. that secondary school teachers of environmental topics frequently used lecture, discussion, and textbook assignments, and rarely used environmental simulation, community service projects, or federal agency materials. In agreement, Barber (1982) found in Illinois, U.S.A. that lectures and discussion are predominant in teaching ecology in secondary school. Despite its predominant use, however, teachers do not see the lecture method as the most effective. For example, Schwaab (1982) who surveyed 117 public school personnel to find out how effective 12 teaching strategies[2] were in teaching

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1- Likely this will remain the same unless, (1) teachers understand precisely the nature and the processes of scientific inquiry, (2) have sufficient understanding of the nature and the structure of biology, (3) become skilled in inquiry teaching techniques, and (4) accept the idea that less structured teaching approaches are valuable and not difficult for most students (Castenson and Lawson,1986). They argue that " Lacking this knowledge and skills, teachers are left with little choice but to teach facts in the less effective expository way" (p.150).

2- These strategies and their extent of use were: Teacher led discussion(92%), Lecture (92%), Individual projects (87%), Demonstrations (86%), Individual reports (86%), Reading (85%), Inquiry (80%), Student led environmental education and how frequently teachers used them, concludes that more frequently teachers used "less effective methods, such as lectures and teacher led discussions, despite the acknowledged higher effectiveness of other teaching methods. Most teachers are aware that the highly effective methods of teaching environmental topics are those which involve students as active rather than passive participants. The following section focuses on the kind of difficulties faced in teaching ecology.

The Difficulties Teachers face in Teaching Ecology

Numerous educators have agreed that the teaching of ecology presents a difficult task at any level, especially in the field (e.g. Booth, 1979; Harper,1982; Wells,1982; Hale, 1986b). Teaching ecology has been seen to pose more special problems, both intellectual and administrative than any other area of biology (Dowdeswell and Potter,1974; Dowdeswell,1979). As a result, ecology topics are poorly represented in teaching syllabuses and examination schemes (Moss and Theobald, 1979; Booth,1979). In this section an examination of the literature with respect to the difficulties of teaching ecology will be made, beginning with the 1979 study by Booth.

Seven reasons emerge from the literature for the difficulties teachers face in teaching ecology.

The nature of ecology

The very nature of ecology presents a problem in teaching it. Booth (1979) claims the subject is elusive as it means many things to different people. He notes, for example, that within the discipline there are many models, each containing specific terms and language to address various hypotheses, which can be confusing to the ecology teachers. Although Harper (1982) disagrees with Booth's claim, he argues that ecology at the school level does not exist as a subject despite all attempts to introduce it. He suggests that

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discussions (80%), Group reports (74%), Independent study (68%),Cognitive skill development (68%), Debates (50%).

ecology should be introduced as a joint theme with physiology[1]. Dowdeswell (1979) saw the problem regarding the nature of ecology on a more basic level than did either Booth or Harper, suggesting it demands a more holistic, integrative approach; an idea that has been replicated in more recent work in Project Wild.

It seems that in order to teach ecology successfully and to fulfill the purpose of ecological education, teachers must understand its true nature and communicate this knowledge to their students.

Confusion in teaching ecology

Booth (1979) summarizes five issues causing teachers difficulty in teaching ecology. These include :

1. The isolation of ecology as a separate topic within a biology or science course rather than treating it as an integral part of the course (cf. Harper, 1982 and Hale, 1986).
2. A tendency to treat ecological work as "project" work lacking the more precise end-points of other experimental [or exercise based] work.
3. A tendency to look for new discoveries in ecology rather than working towards end-points which are within definite limits of which at least the teacher is aware.
4. The use of techniques (e.g. use of quadrants, transacts) without defining what questions are being asked, often for the sake of the technique only.
5. Attempts to take on complicated tasks in which the number of variables involved makes progress almost impossible (the large number of variables which have to be considered in most ecological investigations is one of the major difficulties encountered in studying the subject.). (p. 262)

Dowdeswell (1979) believes that teachers attempt to deal with too many diversified habitats and ask unnecessarily complex questions about ecosystems instead of using

1- He feels that such a theme would (1)-give the course a coherence which a miscellaneous collection of topics would lack; (2)-introduce the students to some large ideas, which their teachers may feel are important, and (3)- provide a criterion for the selection of material to be used in the course. Harper's (1982), rationale for this is " The physiology-ecology theme involves an attitude of mind which encourages the asking of two questions about any biological structure: how does it work, and how does it relate to its environment? Something interesting can be said about erythrocytes at time molecule, gene, cell, tissue, organism, and ecosystem levels of organization, and perhaps others as well; but the immediate environment of the cells the adjacent fluid and other cells. Similarly the immediate environment of a lion may be the ecosystem of the Ngorongoro Crater, while that of a carbon atom may be the molecule it is a part of"(p.126). This, of course, according to Harper, requires that ecological concepts should be fully integrated into other topics, and " consequently the abolition of ecology as a discrete entity"(p.123).

simple analogies from the surrounding community as starting points, and thus encourage an experimental approach to specifically defined questions or problems. Booth (1979) agrees.[1] This confusion leads teachers to use methods which usually result in unsatisfactory outcomes (e.g. a lack of any real understanding among students).[1]

Knowledge and attitudes of teachers themselves have also been cited as a reason for difficulties in teaching ecology. Towler (1980-81) asserts:

> Teachers who are not prepared or trained to teach E E cannot help but have a neutral if not a negative attitude towards the subject and its importance...[and] if they are required to teach it, they will find themselves somewhat disadvantaged in trying to do so. (p. 15)

The need for environmental teacher education at the secondary school level to alleviate such problems seems urgent (Volk, Hungerford and Tomera, 984).

Lack of experience in evaluating students performance in ecology

Booth (1979) and Moss and Theobald (1979) found that students answering ecology questions obtained lower marks than those who answered other questions in biology examinations, even when ecology was a specified part of the curriculum[2]. There is considerable controversy among teachers on how to introduce ecological questions to students and how to examine their knowledge and understanding of ecology. According to Booth (1979):

> Some teachers feel that some form of coursework or internal assessment is essential. There is some relationship between this view and some of the traditional views of ecology teaching. Examination questions may have encouraged the teaching of "theoretical ecology" with little or no firsthand experience. Internal assessment would ensure that data were obtained firsthand. (p. 263)

1- An example of such an analogy was given by Booth (1979): "There is some evidence that starting from issues arising from gardening, fishing, or the keeping of rabbits or pigeons may be more realistic. In some cases conservation work involving physical work has been a successful starting point. For example, a group of pupils given the tasks of cleaning out a stream in Doncaster became interested in the environment and the organisms living in it."(p.262).

1- As I see it from the cited literature, it appears that there are few teachers who really know (1) how to teach ecology; (2) what kind of starting point they should use; (3) what kind of motivation they should spark, and (4) what kind of materials and resources they should use.

2- For example, if students get low marks on the ecological items of the exam, parents and educators might want to eliminate these questions. When these questions are eliminated, it might be reasoned that ecology be eliminated entirely.

Failure to include ecology on the final exam has also been connected to the difficulties teachers face in teaching ecology. It might help to solve the problem if ecological concepts and principles are always included as a part of classroom teaching and student evaluation.[1] If ecology is included in the final exam, teachers will not only teach it, but also develop the skills and techniques necessary for better student evaluations. Eichler (1977) convincingly argued that if ecological and environmental themes were included in secondary school examinations, both teachers and parents might give more serious attention to the subject. Booth (1979) agrees with this view in stating that " unless examinations and their syllabuses demand that ecology is an integral part of biology and science courses, it is unlikely that much ecology will be taught in science" (Eichler, 1977, p. 263).

Lack of teacher confidence in dealing with ecological issues and in identifying local organisms

Many teachers lack confidence, especially regarding the identification of organisms in ecology teaching (e.g., Booth, 1979; Hale, 1986). It is inevitable that teachers who have never been trained to develop identification skills or to use them in teaching will be at a disadvantage. Teachers are aware of this, and they see familiarity with many living organisms of a given area as an important factor in understanding the environment and in teaching ecology. In the U.S.A., for example, high school science teachers rated the "identification of flora and fauna" and the "improvement of habitat for desired flora and fauna " as eighth and eleventh in importance among twenty-seven outdoor natural science activities (Keown,1986). It may be inferred that the development of such identification skills (which includes observation, capturing , recapturing, collecting, recording, sampling, identification and characterizing the species and analyzing data) is seen by those

1- Including ecology as part of classroom teaching and student evaluation however, is not enough. There must be a correlation between demonstrable levels of operational thought and mastery of ecological concepts. For example, only a small fraction of high school biology students consistently demonstrate formal reasoning (Lawson & Renner, 1975; Lawson & Blake, 1976). Yet many ecological concepts taught in high school require formal operational thought in order to be understood (Igesrud & Leonard, 1988).

authors as necessary for every successful biology teacher. Unfortunately, many college biology programs are no longer interested in teaching these things. Yet, environmental education programs "...will not be effective and relevant when animals, plants, and the nature of their habitats are mostly unknown " (Jun-Y, 1984, p.36).

Lack of confidence among many teachers is the result of having little experience in carrying out ecological work; hence, they may have the feeling of entering the unknown (Booth,1979). Harper (1982) agrees with Booth about lack of confidence among many teachers, but disagrees as to the cause of it. He sees lack of confidence as a rational response to the fact that ecology is a difficult subject to teach. According to Harper (1982), it demands an expertise which one can reasonably expect to be expressed in a university lecture on ecology, but is not found in lectures in other disciplines or as part of the knowledge base of the average high school biology teacher. University lecturers who specialize in ecology must possess the necessary knowledge and skills, and the capacity to identify a wide variety of species, as a qualification for teaching ecology. Harper argues that when ecology is a joint theme with physiology in a biology course, less exceptional requirements for teaching field ecology will be demanded. Mariner (1978) suggests that biology teachers should be more aware of their responsibilities to possess appropriate knowledge and skills in order to gain self-confidence and to hold professional respect. Hale (1986) also sees a need to recognize the lack of teacher confidence in ecology education, and she recommends that ecology teacher education (especially in inservice education) be provided if the problem is to be solved.

In short, it seems that teachers with little or no ecology background, in either content or method, will likely kill any interest students may have in the study of ecology, not only in high school, but also in college.

Lack of appropriate facilities

Many schools lack even the most simple and inexpensive equipment for carrying out ecological work (e.g., Booth, 1979; Hale, 1986)[1]. Towler (1980-81) found in his study of Canadian Pre-Service Training in Environmental Education, that there is a serious need for better teaching materials. At the college level, however, Cox (1970) found that the teaching of many structural and functional processes of ecosystems can be improved "by simple methodology and inexpensive equipment " (p. 755).

The field has been recognized by many educators as one of the main facilities in conducting effective ecology teaching, especially when valid information about local educational sites and their organisms, easy organization of students, free time in the school timetable, adequate funding, and small class size (Booth, 1979; Hale, 1986; Keown,1986) are available. Ludwing (1985), who believes that "whole ecosystems cannot be maintained in the classroom" (p.24), suggests that the best way to teach the holistic component of the environmental system is in the ecosystem itself, in the field or at the zoo or museum. He sees ecology as field oriented work where students can, "perceive the complementary relationship of pattern and organized process-with the processes of the whole" (p.24). He adds that "while the difficulty and complexity of field trip participation and learning must be considered, field trips are vital for holistic understanding of systems too large to be studied in the classroom" (p.24). Some editors of high school biology textbooks are also aware that teachers "are most successful in their teaching of ecology when they can get students outdoors" (Barber, 1982, p. 120).

However, other educators have found a different approach successful -- using artificial or substitute environments, instead of the traditional field. Long term experiments can be carried out if indoor and outdoor knowledge is properly utilized (Booth, 1979). Laboratory or artificial environments can sometimes demonstrate the same ecological

[1]-Even where these learning materials do exist, however, teachers, nevertheless, may be unwilling to work with them, or to teach environmental studies effectively because they have never been trained to do so (Sutman1980).

principles that normally may be considered regular field work. "A compost heap, moss tuft, or rotting log close to the laboratory can often lead to just as good ecological work as can a visit to an off-shore island" (Booth, 1979, p.264). Yet, others hold the view that ecology can be taught effectively using lecture and laboratory approaches (e.g. Cox 1970). Cruzan (1988), for example, developed an experimental ecology lab approach based on microcosms to test numerous ecological hypotheses, especially in the areas of population and community. He holds the view that an approach such as this (Microcosm-based ecology labs) has "the advantage of being more subject to experimental control and manipulation. They also eliminate the hassles of field trips...[and] it is a more efficient use of our time and it better presents ecology as an experimental science" (p. 228). The disadvantages of this approach he states, are: "The students have to be reminded that microcosms don't always behave the way communities in the field do. Also, in a small class with time limitations, it is not always possible to collect enough data for satisfactory statistical analysis" (p. 228). Hale (1986), in a field-based investigation involving a combination of classroom, laboratory, and urban fieldwork, has suggested the value of the urban environment of even large cities as an integral part of ecology teaching. In many cases, ecology teaching has become largely a classroom subject favored by only one or two half-day -field work.

A perceived dichotomy between practical and theoretical ecology

Only a few research and course designs have been concerned with the gap between what is taught theoretically in school and what is practically attempted in the area of ecology education. As a consequence, it becomes hard for teachers to maximize educational learning that combines theoretical and practical approaches. Field work, for example, which supposedly involves a practical approach to learning ecology, is usually conducted without any connection to what is being taught in the classroom (theoretical) and as a result is "too often a jumble of unrelated techniques having no clear theoretical framework "(Wells,1982 p. 265). A balance between practical and theoretical study in the teaching of ecology at the secondary school level must be achieved in order to provide effective ecology education. To try to separate science in schools into 'practical' and 'theory' lessons is "...to perpetuate a dichotomy which is the antithesis of true science" (Points, Brown, and Greig, 1971, p. 13).

Lack of emphasis in developing observation skills

In studying biology, observation is the key to stimulating the minds of pupils to think about a particular object(s) or relationship(s) in a given ecosystem. Most of all, observation is essential in the development of concrete thinking. It is the basis for the pupil's development of formal or abstract thought. "Understanding biology increasingly depends upon the development of abstract, or formal thinking" (Ryman, 1976, p.181), because formal thinking is necessary in the formulation and testing of hypotheses. It seems ironic that scientific observation is viewed as neither suitable as a subject of education nor even useful as a guide to science instruction. This is true despite the fact that, "one legitimate goal of science teaching is to promote accurate views of nature and the role of scientific investigation" (Norris,1985, p.818).

Two views emerged in the study of observation skills in the literature. One view is that teachers are required to teach observation only indirectly because of a shortage of time. So, rather than let their students look for something to observe and make their own legitimate inferences, they (teachers) tell them what to observe and what their observations will mean. They ask their students, for example, to determine the characteristics of things, to see the changes in growing things, to learn the habits of animals, and to see the results of experiments, etc. In observation such as this, there is no room for biased, overly subjective observation or rational disagreement between students and/or the teacher.

The other view is that observation is related to complex mental processes, and can only be accomplished through structured observation activity. According to Norris (1985) scientific observation requires "the operation of complex and elaborate mental processes" (p.817). Thus it should be represented at least at the senior levels of schooling as a complex activity "requiring considerable planning, the construction and coordination of complicated apparatus, and much thought in conceiving in the first place what observations to expect" (Norris, 1987, p. 776-777). He insists that:

> Becoming a competent scientific observer is to achieve a complex skill, and is best achieved using an approach which proceeds from the simplest sorts of scientific observations to the more complex kinds, but at neither level portrays scientific observation as anything other than a sophisticated scientific activity. (p.832)

Thus, he adds, students should be confined to simple as well as complex forms of observation throughout all of their public school careers. If observation of the living world is carried on without a structured method Hill (1985; 1986) argues, it will be a sterile educational activity.

Whether it happens informally or as a structured activity, the literature cited above shows that the role of observation in teaching science, and particularly ecology, has not gained adequate emphasis from either curriculum planners or teachers.

How Should Ecological and Environmental Topics Be Taught?

The literature of biology and environmental education indicates that ecology can be best understood through the integration of classroom, field, and laboratory teaching (Hale, 1986). The argument underlying this view is that in the classroom, the understanding of how organisms interact with each other and with their environment is often difficult and can be easily lost in the morass of details teachers try to give about separate and isolated ecological topics and ecologically associated phenomena (Coltta, and Bradley,1981). How can students understand the principles and concepts of ecology if they do not have the first-hand experience of natural processes and their interactions, and/or if they are not able to observe, identify, and investigate the similarities?

Hall (1980) who included the proper teaching of ecology as one of three general research questions in his dissertation[1], states that

> The Wilderness inquiry method, combined with a novel and relevant setting, yielded superior statistical and nonstatistical results over the classroom guided discovery instructional treatment and the control didactic research group in ecological thinking, feeling, and perceiving scores. (Hall, 1980, p. 3514-A)

The advancement of understanding and appreciation of natural processes and their interactions within the ecological system, cannot be fulfilled merely by detailed description of different habitats and the identification of different species (Hale,1986b). Adequate comprehension requires that ecology and associated subjects to be represented to the students in classroom, field-work, and laboratory oriented approaches. Ecology, Cox (1970) argues, must be "presented as a field with clearly defined subject matter, ...emphasizing the complementarity of structure and function in ecological systems, and must provide students with a thorough understanding and appreciation of the process of ecological inquiry" (p. 755, 760). He believes that ecology comprises one of the "most effective fields for introducing students to the nature of scientific inquiry" (p. 755) and Costenson and Lawson(1986) seem to agree. They argue that the modern goals of instruction may not be met unless scientific inquiry is incorporated into ecology teaching.

While elements that contribute to environmental problem-solving are varied (e.g., Hines, 1984; Sia, et. al., 1985-86), the literature indicates that case studies, studying what others do/did to solve environmental problems (e.g., Kaplan, and Monroe, 1988), and participating in real action projects (e.g., Ramsey, et al., 1981) are the most important teaching techniques in helping students become environmental problem solvers. Prior to developing environmental problem-solving skills, the literature concludes that students must have knowledge of ecology, environment, and survival issues necessary for solving these problems.

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[1]-Even though Hall's study is related to elementary school youth, the results of the study could bring some light to teaching ecology at upper levels.

In a study concerned with teaching strategies for tertiary environmental education, Stokes and Crawshaw (1986) argue that since there are different target groups for environmental education at any given time, then, for practical purposes there should be different teaching strategies. They distinguished four target groups for tertiary environmental education, each requiring different sets of teaching methods, strategies, and skills. According to Stokes and Crawshaw:

> The Technical Group needs to know how to measure environmental parameters. The Subject Specialist Group needs to know about environmental systems. The Management Group needs to have the skills and abilities to resolve complex environmental issues and problems. The Lay Group needs to have attitudes, philosophies and values about the environment. Each of these in turn require different teaching strategies. For the Technical Group, practical experimental teaching methods based on the traditional subjects approach appear to be the most suitable. The Subject Specialist Group needs presentational methods based on either an infusion approach or a new subject approach. For the Management Group, a combination of high level disciplinary teaching combined with intensive short skills courses and more extensive 'junction' or 'environmental encounters', all of which make use of practice methods of teaching, are suggested. For the Lay Group, experiential methods, where the student's attitudes are challenged by experiences in either an in-service situation or through simulation exercises, seem to be most appropriate. (p. 35)

In short, the literature seems to suggest that scientific inquiry, problem-solving, reasoning and thinking ability, discussion, and other methods such as role-play, games, value classification, and simulation give students an opportunity to understand how the questions, ideas, and evidence interact, and how students are able to generate questions and ideas of their own and find answers. They also give students an opportunity to become involved in experiences in which their values are challenged. Approaches such as these are thought to provide the best methods for teaching ecology and environmental topics. But while all these teaching strategies play a role in helping students to understand ecological principles and issues, the literature indicates that successful teachers more often use combinations of many teaching techniques. Employing a variety of teaching strategies is the essence of successful teaching.

Summary and Conclusion

Since the current ecocrises stems largely from our underlying cultural assumptions about nature, humankind, science, technological development, and economic growth, teaching approaches which develop awareness and responsible attitudes are needed. Instructional models that fulfill these objectives, must focus on the student as active participants rather than passive participants. This view is based on the theory that learning is best achieved by full student involvement in the learning situation through investigation, discovery, and problem-solving processes side-by-side with the content of scientific claims or explanations. Castenson and Lawson (1986) believe that the modern goals of instruction may not be met unless scientific inquiry is incorporated into ecology teaching.[1] Without inquiry, reasoning and thinking ability, discussion and group investigation methods, they believe we will fail to : a) see effective ecology education; b) achieve the societal goals of science education suggested by both the Project Synthesis and the Science Council of Canada Report - 35 (1984); and c) develop among students the tendency to question the prevailing anthropocentric attitudes and beliefs. Ecology comprises one of the "most effective fields for introducing students to the nature of scientific inquiry" (Castenson and Lawson,1986, p. 755). It must be "presented as a field with clearly defined subject matter,...emphasize the complementarity of structure and function in ecological systems, and must provide students with a thorough understanding and appreciation of the process of ecological inquiry" (Cox,1970, p. 755, 760).

1-Making science relevant to the students (e.g., Harms & Yager, 1981; Levin & Lindbeck, 1979) can be achieved by applying inquiry, problem-solving, group investigation and discussion methods. The discussion of current environmental problems in teaching ecology nurtures the relevancy of students to their surrounding environment (Barber, 1982) as well as broadening the students' knowledge of a given problem. Although most educators agree that the application of ecological knowledge to the discussion of environmental problems and issues (Kupchella & Hyland; 1977) is desirable, there is evidence that most general biology teachers have not being doing so during their teaching of ecology (Barber, 1982).

CHAPTER FOUR
RESEARCH METHODOLOGY

The research methodology of this thesis involved teacher interviews (chapter five), classroom observations (chapter six), biology textbooks and curriculum guide analysis (chapter six), and review of the related literature with respect to trends in biology education (chapter two) as well as the goals, content, and instruction of school ecology (chapter three). Discussions with a panel of scientists, curriculum theorists, science educators, secondary school biology teachers, and faculty associates occurred on a regular basis during the development of the prospective framework. Figure 4.1 & 4.2 provide an overview of a graphic representation of the methodological framework used in this study. The main steps are: (1) developing a prospective framework for ecological education by reviewing related literature and discussing it with a panel of scientists, science educators, curriculum theorists, secondary school biology teachers, and faculty associates[1] (historical and analytical/developmental research), (2) collecting data and information through classroom observation, teacher interviews, and textbooks and curriculum guide analysis (descriptive research), and (3) placing the prospective framework against the data collected through a variety of data collecting procedures (comparative/analytical research). Figure 4.2, 4.3 and 4.4, provides details of where to get information and what to do with it once it has been collected. Figure 4.1 shows the degree of overlap of the various research methods used in this study: descriptive, historical, analytical/ developmental, and comparative/analytical research.

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1 -A faculty associate is a school teacher selected for his/her outstanding effective teaching to work for two years in a teacher education program (in the Faculty of Education, S.F.U)

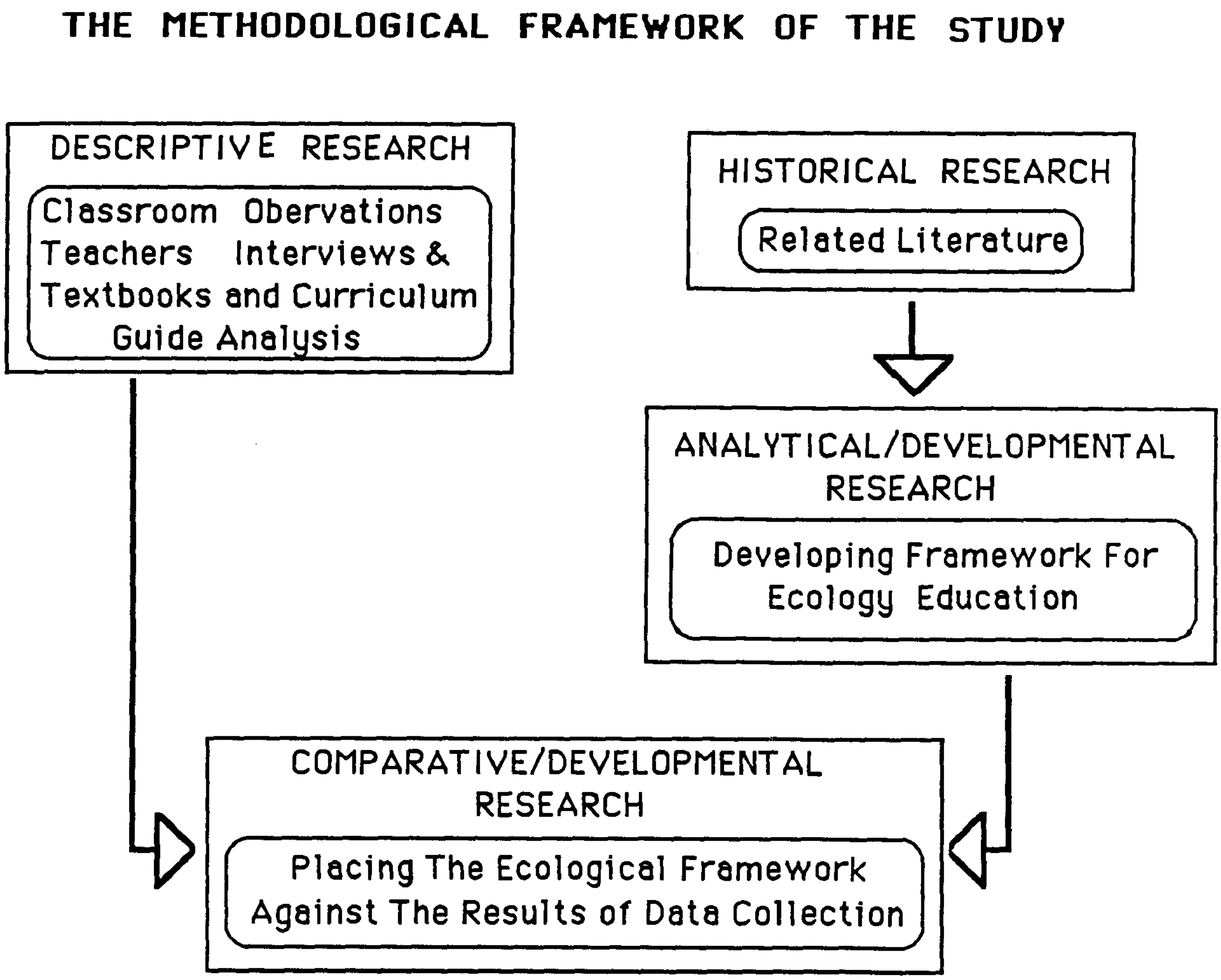

Figure 4.2
The general methodological framework of the study.

Figure 4.2 shows the degree of overlap of the various research methods used in this study: Descriptive, historical, analytical/ developmental, and comparative/analytical research. Figure 4.1, 4.3 & 4.4 of the methodological framework of the study provide further details of where to get information and what to do with it once it has been collected.

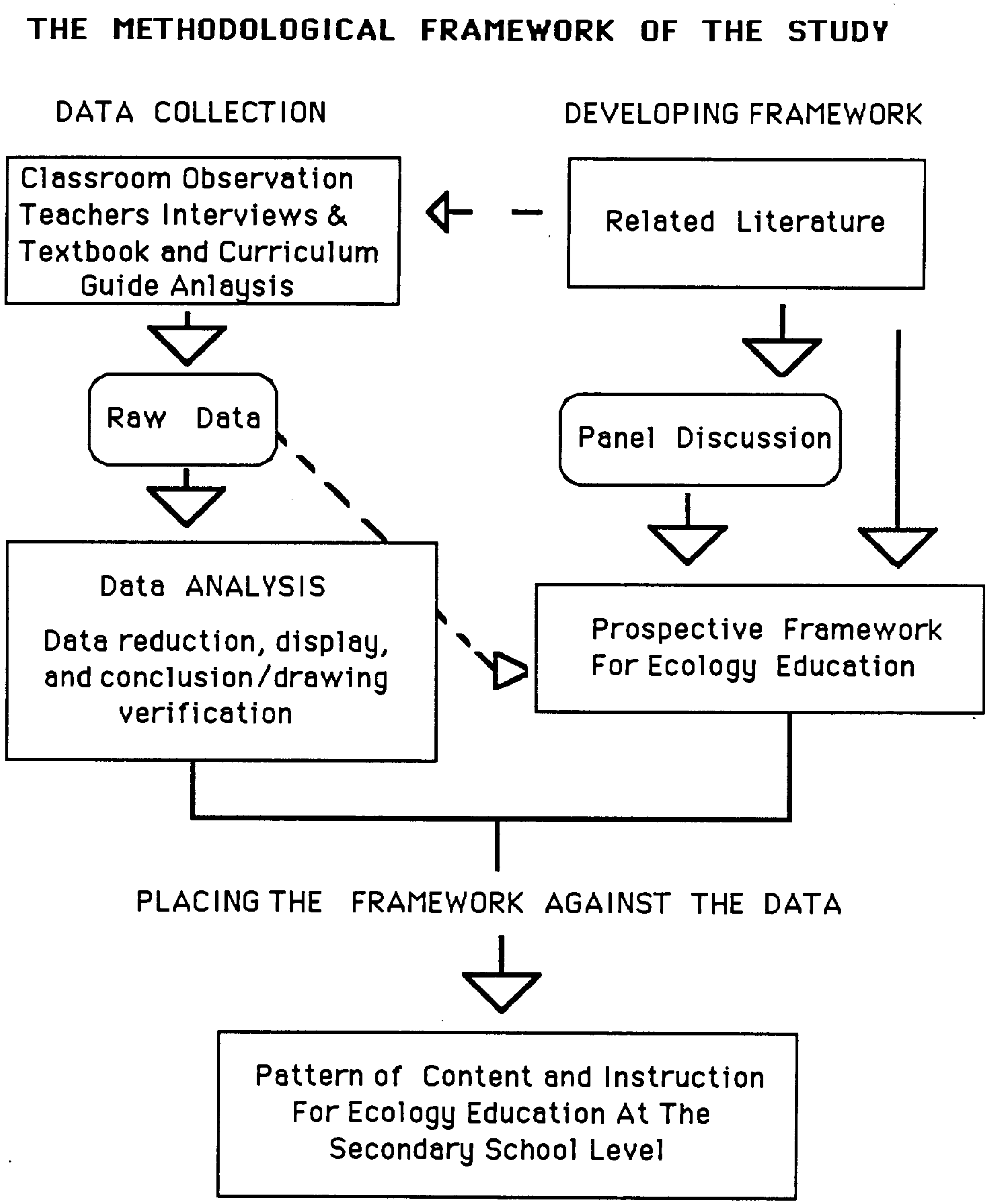

Figure 4.1: This methodological framework of the study provides more details as to where to find information and what to do with it once it has been collected.

Establishing A Methodology

Prior to undertaking this study, I visited three secondary schools in large metropolitan areas in the Lower Mainland of British Columbia to learn about school systems there. I spent two days in each school observing different science classes and talking to high school science teachers and students. I was also a co-investigator in an empirical study which examined the transitional problems of students moving from high school to university science. Some of the tentative conclusions I drew as a result of these activities were:

1). Most science teachers do not like observers in their classrooms, particularly those with a pre-set of items or categories for observation. As one of the biology teachers said,

> We (teachers) are not machines. We are human beings, and we do not automatically do the same thing every day. What we do is holistic, and cannot be seen as a separate item or category on the shelf of the supermarket. Our job cannot be understood without contextual information. After all, we as teachers alone in the classroom ultimately determine the quantity and quality of science instruction to which students are exposed.

As early as 1968, Smith and Geoffry recognized the difficulty of understanding the behavior of teachers by observation alone, with no consultation. Teachers are the only people who can explain why they conduct their classrooms in any particular way. Wideen (1986) and his research team, who agree with Spindler's (1982) and Wilcox's (1982) view, clarify this by saying: "Teacher behavior cannot be properly understood or described separately from the setting in which it occurs "(p. 28). Observation alone, it seems, is insufficient for gathering information about a given instructional activity. Employing a variety of data by collecting procedures is one way of ensuring the flow and validity of the information given (Wilcox, 1982).

2). Teachers feel more comfortable dealing with written surveys than with interviews. In this way they believe that they have more time and opportunity to think.

They prefer to know in advance who will have access to the materials. Teachers also want knowledge of the results.

3) Teachers prefer that the observer should not collect any data or information until he/she has spent considerable time in the classroom or laboratory. Moreover, they prefer that the observer begins to collect data only when the teachers are ready. Thus, developing trust between the surveyed and the inquirer is required to ensure valid results in any survey.

4) It is very important not to mislead participants by giving them the results of similar studies or researcher's preconceptions. Such information can easily invalidate their answers.

As a consequence of (a) consideration of teachers' comments, (b) personal involvement with two empirical studies[1], (c) the purpose of this study, and (d) methodological research works[2], I chose an approach that involved detailed description, and that did not rely heavily on pre-set categories of observation but which involved holistic observation. This means that the reality I am looking for exists beyond the numbers generated by paper and pencil tests completed by the participants. I was influenced by my involvement for one semester in a research project entitled "Problem-Focused Coursework as a Model for In-Service Education: Case Studies of Teacher Initiated Change". Early in this research, Wideen and his research team had reviewed the work that had been done on observational methodology and found that a range of schedules have been developed for use in classrooms. They concluded that:

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[1] -The Transitional Problems from High School to University " and " Problem-Focused Coursework as a Model for In - Service Education: Case Studies of Teacher Initiated Change ".

[2] -" Ecology: Let's Hear from the People-An Objective scale for the measurement of ecological attitudes and knowledge " Malony and Ward (1973), " Social Research: Strategy and Tactics ", Phillips (1976), Qualitative Evaluation Methods, Patton, (1980),"Ethnography as a methodology and its application to the study of schooling: A Review" Wilcox, (1982), "Doing The Ethnography of Schooling : Educational Anthropology in Action. " Spindler (ed.), "Qualitative Data Analysis ", Miles and Huberman (1984), and "Problem Focused Coursework as a Model for Inservice Education", Wideen, et. al. (1986).

> The literature on the classroom study offers observational methodologies for the gathering of such data which range from atomistic to holistic approaches, from category systems' frequency counts of discrete behavior to detailed ethnographic documentations of behavior within contexts. (p. 28)

They add that holistic approaches rely on detailed descriptions to reveal general patterns of teaching, taking into account the context of the classroom. They claim that :

> These techniques seem particularly useful for analysis of the complex activity of teaching with their emphasis on a) the importance of context, b) the need for detailed records and descriptions in field notes, interviews etc., and c) the impact of the perspectives and attitudes of the observer/researcher on both the observation and interpretation of data. (p. 28)

Furthermore, Rowley (1987) argues that "when the researcher is interested in such things as leadership, group dynamics, aesthetic appreciation, environmental ethics, participant expectation, pre-trip anxieties, or post-trip talk for example, qualitative methods may produce the most meaningful data" (p. 10). My own research design is based mostly on such qualitative methodological research.

Naturalistic or Qualitative Research

Naturalistic or qualitative research is now a widely accepted method of inquiry in science education. Today, it is a popular research method and current literature based upon it provides an holistic overview which enables qualitative researchers to move beyond defining the legitimacy of their craft (Herriott & Firestone, 1983; Miles & Huberman, 1984a; 1984b), to ask questions, answer different kinds of questions, and readdress old ones (Fetterman, 1988). But first and foremost, it provides meaning to what is seen, described and interpreted. In other words, it goes beyond the "description of" to include the "meaning of" what the researcher sees, hears, and feels.

The qualitative interview has been described as one of the most valuable and flexible frameworks in research inquiry. It allows the respondents to fully participate and totally express their own understanding in their own terms (Patton, 1980). Qualitative semistandardized interviews (with a combination of both guided and open-ended questions (Borg & Gall, 1983)) allows the interviewer to have both "a number of specific questions to ask ...[and] freedom to follow up whatever he thinks important in his own way"(Phillips, 1976, p. 228).

Miles and Huberman,(1984) suggest that in such research activity[1], some direction is needed prior to data collection, thus several general clusters of things in the classroom were identified both from the literature and school visits. The clusters included (1) model of teaching, (2) source of teaching, (3) discussion of social issues and environmental problems, and (4) classroom context. Since the data is mainly collected from verbal reports of qualitative interviews and observation, it is logical to analyze data through qualitative procedures. Thus, Miles and Huberman's (1984a) procedures for qualitative data analysis which include data reduction, data displays, and conclusion drawing and verification, were adopted. This procedure has been recommended for its usefulness, credibility (Miles & Huberman , 1984a), and quality (Wideen, et. al, 1986).

The naturalistic approach, (using tape recordings, transcripts of classroom observations and in depth interviews), when supported with field and literature review notes, can be a powerful instrument of research methodology. Although it lacks breadth, it does give a depth of detail which in turn leads to new insights and understanding of the phenomenon being studied (Rowley, 1988). In other words, it does not contain a large sample of the population and therefore it does not contain, "a means of checking one hypothesis on a larger sample" (Shayer, 1986, p. 850); or as Miles and Huberman (1984a) put it, "[a]re the cases examined a reasonable sample of a larger universe ?" (p. 15). It also takes time, energy, and requires the researcher to be "...the major 'instrument', not a procedural prescription..." (Eisner, cited in Willis, 1978, p. xiv). Yet, it is preferred by many for its ability to provide meaning to a given social setting. It does require, however, that the inquirer, familiar with the problems in the qualitative research in both data gathering

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[1]-Holistic observation of instructional activity was the chosen instrument because it is not fully predetermined. There is no check-list because it is hard for researchers to know exactly what they would see in observing classroom teaching (Wideen, et. al , 1986). Furthermore, in pre-set instrumental measurements of observation, researchers might in their effort to record all the pre-set elements, ignore others which were not pre-identified (Mash and Makohonink,1975 ; Wideen, et. al, 1986)

and analysis techniques, maintain a reactive relationship with the subject under investigation, and attribute the action only in terms of a multiplicity of interacting forces (Rowley, 198).[1] In short, smaller scale surveys (such as in interview, observation) provide "...close observation, validity of measurement, and experimental control for sample size and breadth of generalization" (Walberg and Shanahan, 1983, p.9).

Data Collection

Background

An interview and observation guide was developed as follows: First, I searched for ideas, concerns, and questions through a review of the related literature, classroom observations, discussions with high school science teachers and students. These items were then incorporated into a questionnaire. The questionnaire was then field-tested using three people (two biology teachers and one science faculty associate) on two occasions, and revised in accordance with their ideas and recommendations. Next, I was asked (by the Senior Supervisor) to justify each statement or question in the questionnaire in terms of why it was being asked and how to use the the collected data from it. The interview and observation guide was then, discussed in the "Proposal Defense" with the committee members and revised in accordance with their ideas and recommendations.

The final revised interview and observation guide consisted of twenty-four statements related to the research questions. A copy of the interview guide is included in the appendix 4.1.

Data collection took place during three school semester (Fall, 1985, Spring, and Fall, 1986). Follow-up visits to nine participants took place during the data analysis to clarify some of their statements and/or a given observed teacher's behaviour.in the classrooms.

1- Also, using a variety of research techniques was recommended for collecting data in qualitative research to ensure the flow and validity of data (Wilcox, 1982).

Teacher Interviews

In the teacher interviews, five groups of research questions were asked. These centered around personal awareness, ecology educational goals, ecology educational content, ecology educational instruction, and general research questions.

The personal awareness questions were designed to identify whether those surveyed are aware of environmental problems. It is widely believed that what is more important than the certainty of ecological crisis, is whether individuals and societies believe there are environmental problems and are willing to do something about them. Keller (1979) asks, "...is there a new awareness that is destined to change our life-style, morals, ethics, and institutions, or is the environmental revolution just another prestigious fad that interests the intellectual community?" (p. 4). In addition to this, "the teachers' understanding of the nature of their subject and why they wish to teach it, coupled with the effect of the teachers' personality..." (Barrow, 1985, p.8), which reflects their beliefs, attitudes, and values, is claimed to be crucial to successful education.

The 'ecology education goals' questions were aimed at identifying the goals of teaching ecology at the secondary school level from the perspective of the secondary school biology teacher. A list of aims and objectives for science teaching in senior high schools, identified by the Science Council of Canada (1983), was provided to those surveyed.

The 'ecology education content' questions were designed to identify exactly what instructors would like to teach in ecology classes. This group of questions also attempted to identify, in part, the interrelationship between questions of "what" and "how" in teaching ecology.

The 'ecology education instruction' questions were designed to clarify both how ecology is taught today in secondary school science, and how teachers believe that it should be taught. At this stage of the research, I provided those surveyed with a list of various teaching models to help them identify their own way of teaching. I also provided them with a list of factors related to poor ecology teaching practices (most of them identified by Booth (1979)). In this way I hoped to identify the interrelationship between the questions of "what" and "how" in teaching ecology.

The 'general research questions' were designed to motivate those surveyed to give more details in questions when I felt that more detail was necessary. In addition, the aim was to give the researcher, "...the freedom to follow-up whatever he thinks important in his own way. He may perform such follow-up during the interview within the context of particular questions and/or after the formal phase of the interview is over" (Phillips, 1976, p. 228). These questions put the interview in a semistandarized framework. Some of the questions in the general research category, were given to all surveyed while other questions were given to individual participants depending on how those respondents answered the other groups of research questions.

Interview framework. Of twenty-seven secondary school biology teachers asked to participate in this study, I interviewed twenty[1] (over 10 % of the total population of public secondary school biology teachers in the lower mainland of British Columbia). Those interviewed were drawn from different lower mainland metropolitan secondary schools and those observed were drawn from two schools in the same urban area[2]. All these teachers had been teaching biology at the secondary school level for at least 8 years and six had taught for more than 12 years (three have been teaching for 17 years). Each of the 20 teachers was interviewed during one session lasting 45-70 minutes. Before the interview, I also visited each of them to discuss the study, and provide them with a summary sheet of the aims and methodology. Agreements to be interviewed and/or to allow me to observe, and schedules for these activities, were made in following visits. Immediately before every interview started, the teacher was informed that they should only answer those questions

1- The other seven teachers felt uncomfortable to be interviewed regarding ecology education in their schools, and thus refused to participate in this study.

2- Prior to this study however, I observed many secondary school science teachers in three other high schools in Vancouver B.C.

that they feel comfortable about. More males (85 %) than females (15 %) were involved in this study.

Scientific terminology in the presentation of questions was avoided and use was made of the terms introduced by the teachers and faculty associates during the initial search for research questions. The interview questions were given to each participant in a fixed order, but in a setting which provided an opportunity for the researcher to follow-up the questions and to probe the reasons behind the initial responses. Questions inviting a simple yes/no response were also avoided as much as possible.

Qualitative Observation of Teaching Ecology

Background One of the main sources of data collection in this study was classroom (field) teaching observation, using the holistic approach. In addition, some of the class sessions were audiotaped to increase the precision of the researcher's observational efforts. This taping is recommended by many experts in the field (i.e. Wilcox, 1982; Borman, 1978; Spindler, 1974). Originally, I planned that six class sessions be audiotaped, at least one from each teacher being observed, but only two of these six teachers allowed me to audiotape their class. Furthermore, only three of these six teachers allowed me to observe them as many times as I wanted to. The rest of the participating teachers allowed me to observe only once or twice. However, they were willing to talk with me any time I wanted. Therefore, six secondary school biology teachers were observed. Three of these six teachers were observed an average of ten times each. The others were observed two classes in a row twice each. Each observation lasted an entire 45 minutes class period.

All the observations took place in two schools. One of these schools had an adequate environment for the enhancement of teaching and learning. It had labs, a green house, and it was near a park which featured a small area of thick trees, streams, and a river. It was also close to some industries. The school environment in general, and classroom in particular, had what Komisar (1968) calls "learner-enhancement" that is it had the means to "maintain the learner in a fit state to receive instruction" (p.75).

Before the observations were underway, I made at least four visits to the classes of each observed teacher and I participated in the classroom activities as all the students did. Before each teaching session, the teacher and I had a brief discussion about what he/she was going to teach and how. Another discussion took place at the end of each class. The aim of these discussions was to prevent errors and misinterpretations.

Observation Framework. During each teaching session, I made notes relating as accurately and fully as possible to the instructional activities, the previously mentioned clusters, and everything that I felt was important. At the end of each session, after a brief discussion with the teacher, I went to a different room to transcribe the notes of "thick-focused" description. Techniques such as these have been recommended in much of the methodological literature (e.g., Geertz,1972; Wideen, et. al,1986). The four families of teaching models, proposed by Joyce and Wiell, (1983) were used as criteria to identify the common teaching strategies in biology and ecology classrooms. These four families of models are: (1) Informative-Processing Models; (2) Personal Models; (3) Social-Instruction Models; and (4) Behavioral Models.

Data Gathering Procedures

Table (4.1) shows a data summary of device techniques employed in classroom observations, teacher interviews and other data resources for this study.

Data Analysis

After the data was collected, it was stored on computer discs. The data was then organized into an extended text for analysis. After reviewing the raw data, five separate files were formed based on the five groups of research questions in the teacher interviews.

Raw data was then stored in the appropriate files. All the answers to each question were then gathered together and filed with that question. Key words and phrases in the data context were highlighted and themes were identified and later used to display and classify the data for final analysis (See appendix 4.2a, b,c, and d as examples). At the end of the data analysis process, a detailed and descriptive written report was prepared. Since many believe that direct quotations might add credibility to the description or interpretation of a given event (e.g., Lofland, 1971 ; Lofland & Lofland, 1984), relevant quotations were used to make the conclusions as credible as possible. This technique was recommended by many experts in the field (i.e., Lofland, 1971; Wilcox, 1982). Lofland (1971) for example states that "...quoting and describing in an analytic context [is]...the heart of qualitative analysis" (p. 128). According to Lofland & Lofland (1984) this technique not only provides readers with direct access to the data, but also gives them the opportunity to draw their own observations and conclusions. Data from classroom observation were treated in much the same fashion as the data interviews.

Table 4.1
Data Summary of Device Techniques

Procedure Technique	Purpose
Audiotape	To record all the interviews, some classroom teaching, and some of the panel discussions.
Thick-focused Description	To report and maintain educational events in teaching ecology in the classrooms and in the field.
Contact Summary Log	To maintain a record of visits and to report on the school environment.

Developing The Prospective Framework

In developing the prospective framework for ecology education that should represent a rational model of one view of what the nature and the practices of ecology teaching ought to be, I have analyzed related literature with respect to trends in biology education, and the goals, content, and instruction of teaching ecology at the secondary school level. In reviewing the literature, as seen in figure (3.4), I have attempted to identify ideas, themes, emphases, and conceptual structures that promote the development of the framework. In addition to this, discussions with a panel of scientists, curriculum theorists, science educators at the university and secondary school level, and faculty associates have been held on a regular basis during the development of the prospective framework.

The discussions with the panel of professionals cover fundamental concepts for ecology education in secondary schools that are necessary for a) achieving an accurate understanding of ecological systems and healthy-sustainable ecosystems; b) developing positive attitudes and behavior toward the environment and world ecology; c) educating students about the ecological ramifications of their decisions, and d) developing desirable ecological value systems, motivation, and ability to take action. All of these are believed to be necessary conditions for developing ecologically educated persons who in turn are capable of developing an ecologically cultured world.

Checks and balances on the procedure

First, a variety of data collecting procedures were employed to ensure the flow and validity of information (Wilcox, 1982). Second, Miles and Huberman's (1984a) methods of data analysis which have been widely used in similar research were adapted. Third, Wilcox's (1982) strategy to place oneself in a position both "...to observe behavior in its natural setting and to elicit from the people observed the structures of meaning which inform and texture behavior" (p. 458) was adapted. Fourth, Dr. M. F. Wideen as well as a graduate student randomly attended some of the observed biology classes, talked to secondary school biology teachers, and checked some of the classroom observation notes. Finally, two members of my committee (Dr. R. Barrow and Dr. M. Wideen) were asked to check the accuracy of the written report in comparison with the teachers' comments.

DATA COLLECTION

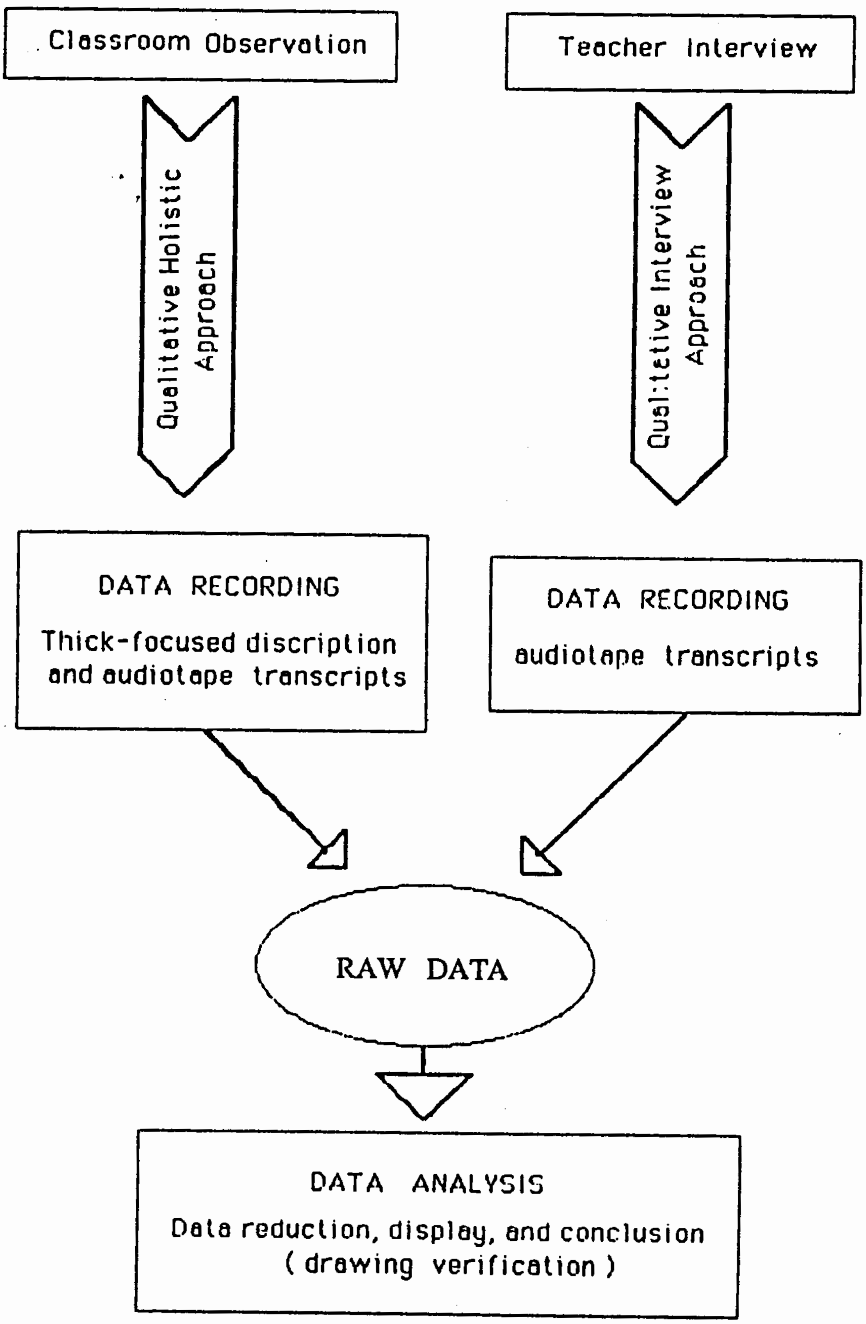

Figure 4.3 of research methodology provides details of where to get information and what to do with it once it has been collected.

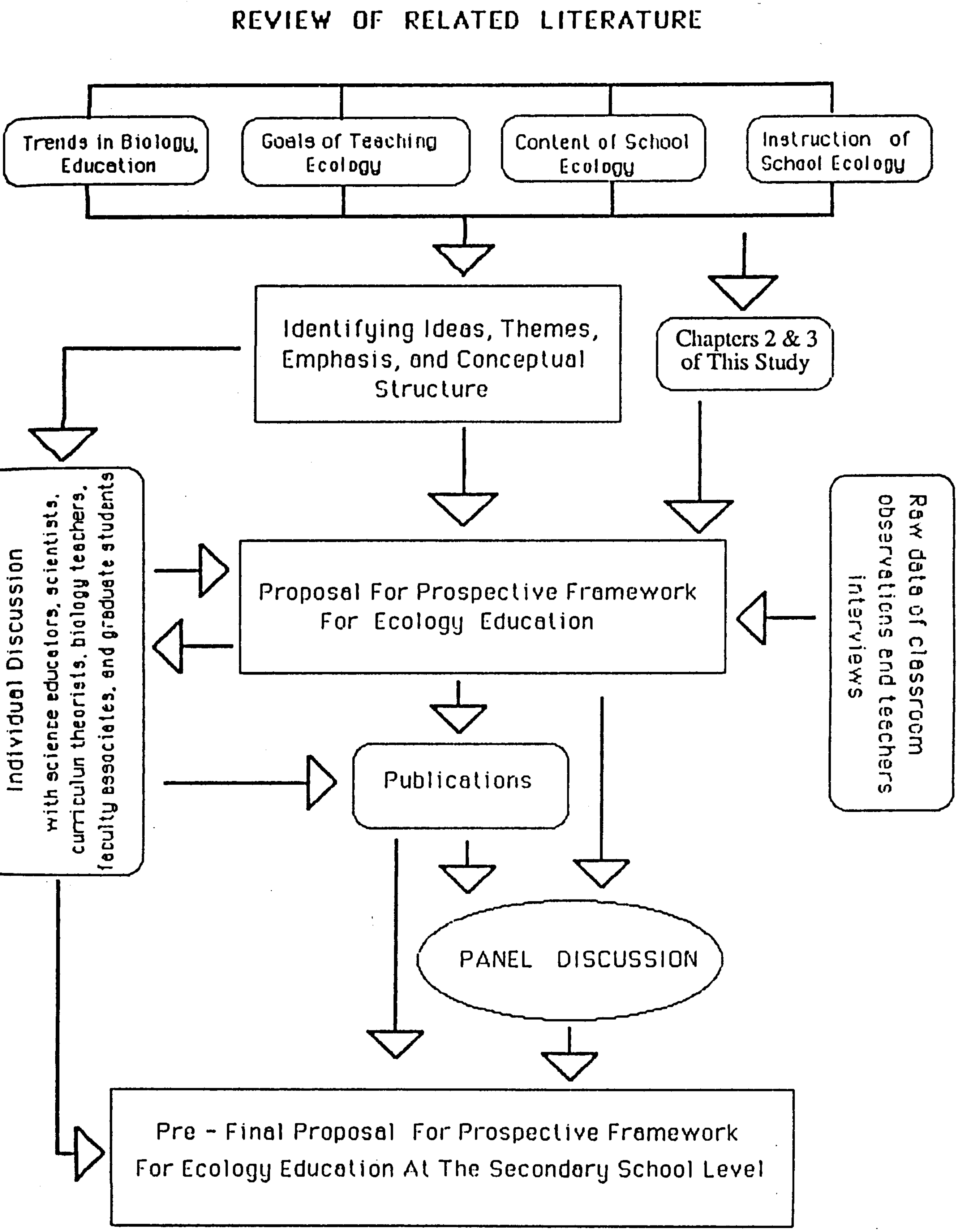

Figure 4.4 of research methodology provides details of where to get information and what to do with it once it has been collected.

CHAPTER FIVE

SUMMARY AND FINDINGS - I

This chapter describes a) the results of interviews with school biology teachers and b) teacher observations conducted to gain better insight into the nature and methods of ecology education in Lower Mainland British Columbia today.

Teacher Interviews

In this section, a summary of the answers given by teachers during the interviews is provided. Where a quotation is used, it represents the view of most participants unless otherwise stated.

Personal Awareness Research Questions

Participants were asked four questions related to personal awareness. Each question appears in italics.

Q.1- Is there an ecological crisis on the earth, and if so, how serious is it?

The following table (5.1) provides a summary of the teachers' views on this question. As shown, eighteen teachers stated that an ecological crisis exists today and fifteen of them described the status of the problem as serious. One teacher describes the ecological crisis in this way, "it is going to be more serious before we can rectify it, should we choose to. The law of Nature applies to all and we have chosen to go against that in many respects." One teacher indicated it may not be as serious as 20 years ago.

Table 5.1
Teachers' views (n=20) of the existence and the status of ecological crisis.

	The Existence of The Problem			The Status of The Problem		
	Exists	Doesn't Exist	Neutral	Serious	Not Serious	Neutral
Teachers Views	18	-	2	15	2	

Participants differed as to whether, and to what degree other people are aware of an ecological crisis. For example, while one person thought people have become increasingly aware of the ecological crises through the risk to public health, four teachers indicated that many people were unaware of it; three believed that awareness has declined since the 1970's. One teacher thought only educated people were aware of the problem.

Teachers were unsure of and/or differed in opinion as to the causes of ecological problems or why they are increasing. One thought that the problem is increasing rapidly because of increased industrialization. Another teacher asserted, that "the problem is magnified because our consumption of energy is increasing at an alarming rate as a result of all the material things that perhaps our society deems necessary." In addition he stated, "there is the fact that we are ignorant about these things and the harm we are doing to ourselves and the environment because schools are not covering that much." On the other hand, one teacher appeared to believe that while we don't know what we've done, but we've surely done something.

In summary, almost all the participants share the view that we are experiencing an ecological crisis which is serious enough for society to need to do something about it.

Q.2-What will it take to awaken an environmental consciousness toward a more sustainable society from a biology teacher's perspective?

Table 5.2 provides the summary of the teachers' views of question two. Six teachers thought that through education we might be able to develop an environmental consciousness. One teacher in this group said, "certainly we can attempt to educate the masses through the media, and I think this can work to a degree ... but I think the most effective way of dealing with this is to educate students." Another stated, "if people know what the problem is and the price that will be paid, then they will mobilize and do something about it." Another, who believed teachers are having an impact on students, stated "students who study enough biology will have the opportunity to develop a social consciousness toward the environment, because students are made aware that all is not well and that there are problems and there are alternatives."

Table 5. 2
Teachers' views (n = 20) of what it will take to awaken an environmental consciousness among people

Views	Catastrophes	Education	Disaster & Education	Politics	Neutral	Total
Participants	5	6	3	3	3	20

Five other teachers, on the contrary, feel that ecological disasters (such as Three Mile Island, the Chernobyl nuclear catastrophe, the Rhine River, the Ethiopian famine, etc.) are what might promote people to think seriously about these issues.

To cite an example: one teacher said "teaching is not going to do it; it is going to make people aware of what, if anything, to do when the crisis comes. But, it will have to be crisis that strikes each person individually." Another teacher asserted that the difficulty is the scale of the disaster, which might be irreversible. Two other teachers believed that each individual and/or every geographical area has to experience a personal disaster before it is seen as a problem that must be solved.

As shown in table 5.2, three teachers shared the view that the combination of crisis and education would stimulate greater environmental consciousness. One teacher who thought people were moving farther away from the positive environmental attitudes which arose during the 1960's, stated "I don't know if anything other than radical changes in the way we live will tip the scales....Most people don't have any idea as to what hit them; they don't have any idea of science, ecology, etc.; they feel helpless."

While three teachers were neutral or unsure of the answer, three others associated the problem and its solution with political decisions. For example, one teacher proclaimed that there is already ample environmental consciousness but it has not yet reached a political decision-making level. Another teacher asserted that "it has to be done politically, but when the dollar is involved, I can't see the government taking this stance to solve ecological problems."

In summary, education, catastrophe, or a combination of the two were the factors regarded as necessary to awaken in the population an environmental consciousness toward a more sustainable society. A common preliminary was, "I don't want to think this way, but..."

Q.3-What is the need for education today regarding world ecology, and how well are school s equipped to teach ecology?

As shown in table 5.3 nine teachers indicated that the need for education regarding ecology was crucial, while seven others asserted the need was significant. One teacher said that the subject of ecology should be mandatory, as are Mathematics and English. Another teacher stated, "if we are going to turn some of these things around, we have to have a better educated public. At this point, effective programs do not exist nor are there people trained to teach them. We need to emphasize the kind of education that makes students aware of the environment and what we are doing to it." Still another teacher suggested that,"...ecology should be included in all science courses through K-12 to be part of the course requirement, and all teachers should teach it."

One teacher felt there was only a slight need for ecological education because the interest was not great enough. "These kids are not suffering from any ecological problem right now, so they don't worry about it ... [Ecology] just gives them some background information, so when something comes, they know what to do about it."

Table 5. 3
Teachers' views (n=20) of the need for education regarding world ecology

Teachers' Views	Number of Participants
Crucial need.	9
A significant need.	7
A slight need because the interest is not great enough yet.	1
Irrelevant question since in today's school system it is impossible to teach ecology.	3

As shown in table 5.3, three respondents felt the question was irrelevant, since in today's school system it is impossible to teach ecology. For example, one person said, "Kids develop their own assumptions and attitudes from their parents, T.V., etc. They don't listen or accept a teacher's assumptions. Schools don't drive toward educating people but they respond most of the time to money and politics, not real issues." Another teacher claimed, "In B.C. we have had cut-backs financially, we have very strict guidelines for science courses, we are dealing with content more than anything ever before, we are restricted to small, very quick experiments in the classroom."

Table 5.4 provides the summary of teachers' views as how well schools were equipped to teach ecology.

Table 5. 4
Teachers' views (n=20) regarding how schools are equipped to teach ecology.

Teachers' Views	Number of Participants
Well equipped	3
Ill equipped.	4
Neutral and/or unsure.	13

While one teacher indicated that schools in industrialized countries are over-equipped to educate people, another teacher thought that schools are not well equipped in terms of trained teachers and staff aware of the ecological crises and the need to do something about them.

In summary, the majority of participants (16 teachers) shared the view that there is a crucial and/or significant need for education today regarding ecology. Yet, most of the them (13 teachers), were neutral and/or unsure whether schools were well equipped to teach ecology.

Q.4-How comprehensive is the treatment of science and society in high school biology textbooks in terms of controversial aspects, questions of ethics and values, the global perspective, and the interdisciplinary nature of the problem?

Views on this question are summarized in table 5.5 & 5.6 below. As shown, teachers' views were divided into two categories: first views on the presence of ethical and value questions and the global perspective in high school biology textbooks (table 5.5), and second, views on the reasons why there was a lack of issues such as these in high school biology textbooks.

Most of the participants (8) shared the view that most biology textbooks minimize and/or shy away from controversial aspects, ethical questions, the global perspective, and the interdisciplinary nature of the problem. Five teachers asserted that some textbooks do address issues such as these, while others do not. Three other teachers, however, felt that biology textbooks do not shy away from these issues. One teacher thought it was a teacher's job and not the textbook's, to provide controversial aspects, ethical questions, and the global perspective. One teacher said, "Controversial issues would not normally be put in textbooks because they are controversial; they need specific guidelines as to how to deal with them. Yet, ethics and values are in the optional part of the back section of the curriculum."

Table 5 - 5
Summary of the teachers' views of the treatment of controversial aspects, questions of ethics and values, and the global in high school biology textbooks. (n=20).

Views	Number of participants
Most biology textbooks minimize and/ or shy away from issues such as these.	8
Some biology textbooks avoid these issues but some others (such as Green Version) do not.	5
Biology textbooks don't shy away from issues such as these.	3
We have just started to include these issues in B.C.	1
Textbooks don't contain and are not supposed to have controversial issues.	1
It is not the textbook, but the teacher's job to provide them to the students.	1

The reasons seven teachers gave for the lack of controversial aspects, ethical questions, and the global perspective in high school biology textbooks, are summarized in table 5.6. As shown, three teachers appeared to believe that the school boards, who buy the texts, are so influenced by the present governmental views that the only texts selected and/or written are those that avoid ecological issues. For example, one teacher said, the problem in B.C. is the resource based industry "which controls the bulk of the tax dollars and the government is jumping to the tune of those tax dollars. There tends to be a self-righteous approach." Another claimed that "there is a change in the textbooks towards a more conservative, less naturalistic, less ecologically oriented perspective which shows a whole political shift in society." The rest of the teachers' views of this issue varied in specificity as shown in table 5.6.

Table 5 - 6
Summary of the teachers' views of the reasons for the lack of controversial aspects, questions of ethics and values, and the global perspective in high school biology textbooks.

Views	Number of participants
Political influence on school boards who select textbooks and in turn textbook writers.	3
Lack of much related knowledge in the past that can be incorporated in all textbooks.	1
Textbooks have been watered down over the years and they are particularly not up to date.	1
Text books have shifted to a more traditional biology.	1
Controversial issues need specific guidelines, how to deal with them.	1

Eight teachers commented specifically about the BSCS Green Version, seven positively and only one negatively, in terms of providing material on controversial issues, ethical questions, and the global perspective. Indeed, the BSCS Green Version was the only regularly mentioned biology text.[1]

1 - One teacher, involved in the textbook writing process, had a very strong opinion against the Green Version. He said that "I, for one, don't ever want to see BSCS come in again. ... I know that it's almost against what we are all taught, but I find the materials frustrating." This same teacher said that this year we adopted American texts because they are clear, easy to read, and are understandable. With the pressure of governmental exams, which these kids have to pass, they really appreciate the clarity that they have received

In summary, the majority of the teachers who answered this question shared the view that most biology textbooks minimize and/or shy away from controversial aspects, ethical questions, the global perspective, and the interdisciplinary nature of the problem. The view that some biology textbooks avoid these issues, but others (such as the Green Version) do not, is also shared by many teachers. Political influence on school boards (who select textbooks and, in turn, textbook writers) was the most common reason given for the lack of controversial issues in high school biology textbooks.

Conclusion for group one of research questions Most of those surveyed expressed an awareness of world ecology and some of its associated issues, in terms of having opinions and being able to qualify them. Most of those surveyed thought human society is experiencing an ecological crisis. Opinion was divided as to whether schools are well equipped to educate people ecologically, but it was generally agreed that there is still a need to make people aware of their own environment and what they are doing to it. Most of the teachers felt that to awaken a positive environmental consciousness, we need more education, an ecological catastrophe, or a combination of the two. While most teachers shared the view that high school biology textbooks shy away from controversial issues, ethical questions, and the global perspective, many teachers thought the BSCS Green Version biology textbook dealt better than other texts with these issues.[1]

Goals of Ecology Education Research Questions

In relation to the goals of ecology education, participants were asked four questions.

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with these texts.

[1] - It is not surprising however that those surveyed expressed awareness such as this since they are a homogenous population with more or less the same educational background, residence, and other social dimensions such as (to some degree) income and occupational prestige.

Q.5-Do you teach ecology topics in your biology 11 and 12 classes, and if so, how do you rate the importance of teaching ecology in comparison with other biology topics?

Even though sixteen teachers indicated that ecology is too important to be left out of school biology courses, as shown in table 5.7, only eleven teachers stated that they integrate ecological topics into their biology curriculum. Two other teachers asserted that they used to include topics in ecology, but no longer. For example, one of those two teachers said, "I do select some topics to teach, [but] I am guilty this year of not teaching ecology, or teaching only theoretical aspects of it because of lack of time." Another teacher, who taught grade 12, and yet didn't teach ecology, asserted that, "I tended to stick to the animal, the human physiology, the plant physiology, etc., because there was a government exam that would test on those subjects. Ecology has never been on the grade 12 governmental exam. We've had to drop a lot of our options. Ecology was probably 20-25% of the old biology course. It was pretty good, I thought, and the kids seemed to enjoy it."

On the question as to whether or not they teach ecology, four teachers were neutral or avoided answering.

Table 5 - 7
Teachers' views (n=20) of whether or not they teach ecological topics

No. Views	Number of participants
a - I do often select a number of ecological topics to integrate into my biology teaching.	11
b - I used to integrate some ecology topics into my teaching, but not recently.	2
c - I do often select a number of ecological topics to teach. But sometimes we don't teach ecology in this school.	1
b - I do select some ecology topics to teach when I have enough time.	1
e - I didn't teach ecology in grade 12.	1
f - Neutral in the whole or in the first part of the question (whether or not they teach ecology).	4

Four teachers, however, claimed that it depends mainly on the individual teacher as to whether ecology is selected as the optional subject or not. For example, one teacher explained that "ecology is important and the biggest unit I teach is ecology, but I don't know if I will be able to do this next year when I use the new biology program, because most of the ecological topics will be optional." Another teacher said, "I think ecology is important...but it depends on the individual teacher's interest whether or not to teach it. For example, teachers who are teaching for the governmental exam, would have no reason to spend time teaching ecology." Still another teacher stated, "it is important, but because of the cutbacks, we do not go on field trips anymore. So, we are doing ecology in the classroom, using the kind of textbooks that help us to do so. A lot of ecology we do now is what might be called traditional ecology." He added, "in our school, ecology in grade 11 is taught at the end of the year because it is a subject that we can get rid of if there is not enough time. So, sometimes we don't teach ecology in this school." Two of these teachers explained that they thought ecology was important and they chose to teach it because they are ecologically oriented teachers and/or they are environmentalists.[1]

In summary, even though the majority of the participants believed in the importance of ecology, only half of them (11 teachers) selected ecological topics to integrate into their present teaching of biology courses. The reasons for excluding ecology coursework were, the lack of ecological questions on the governmental exam, the structure of the new biology curriculum 11&12, and a lack of sufficient time for the core of the biology curriculum.

1- To cite an example, one teacher said: "I don't teach ecology as a separate topic, but I do teach it as an overlying theme, relating the organisms and their roles in the environment. I think it's very important. I'm kind of sorry to see it dropped as a core topic, but I really didn't think it fits in at the grade 11 level. I thought it really belonged at the end of the grade 12 course when you can get out and do some fieldwork and then have a base to build on. Ecology isn't anywhere in the grade 12 course as far as I can see... It [governmental exam] would prevent it. Also, the way the course is designed prevents teaching ecology. Before (the old course), we spent two months on ecology . It was probably 20-25% of the course."

Q.6-What should the goals of ecology education be at the secondary school level?

Table 5.8 below provides a summary of the most frequently mentioned goals for ecology education from the biology teachers' perspective. I found it significant that almost all teachers shared the same views. These goals were to develop ecological awareness, appreciation and/or understanding of man's place in the ecosystem (mentioned 12 times), and to develop responsibility through developing skills and processes of investigation and evaluation of issues, etc. (mentioned 9 times). Parallel goals were understanding the nature of an ecosystem and the environment, and developing critical thinking necessary for understanding issues such as these.

Table 5.8
The most mentioned goals of ecology education (n=20).

Views	Number of times mentioned
Awareness and appreciation: to develop within students an appreciation of the environment and an awareness of environmental problems that are associated with being a member of the human race on this planet.	12
There is a need for goals in teaching ecology. The need is for attitude toward developing environmental behavior such as investigation, evaluation of issues and taking action (Ecological responsibility).	9
Understanding the nature of an ecosystem and/or planet earth as an integrated unit.	4
Developing critical thinking necessary for understanding the fundamental nature of an ecosystem.	2
Neutral / Unsure	3

One teacher explained that there was a need for goals in teaching ecology because recently it has become common for some teachers from different subject areas to be called on to teach science. A good set of goals and an adequate ecological framework could help those teachers. A few teachers also noted that some instructors never took ecology courses in their education. Yet two teachers claimed that developing goals such as these takes a lot of planning and development before they can be implemented.

In summary, goals mentioned by the majority of the participants (18 teachers) can be categorized as follow: (1) Developing an ecological background and understanding ecological concepts and principles. (2) Developing critical thinking abilities, which includes developing the ability to respond critically to environmental issues and problems. (3) Developing positive ecological attitudes, which includes an interest in ecology, appreciation of the environment, and a willingness to act in an ecologically responsible manner in daily life.

Q.7-Which of these aims and objectives are most emphasized today in teaching biology and ecology at the secondary school level? (A list of aims and objectives was given to each teacher to comment on)

The following table 5.9 provides a summary of the teachers' views on both questions seven and eight. As shown, the science content and scientific skills and processes were mentioned sixteen and nine times respectively, as the most emphasized aims today in teaching biology and ecology at the secondary school level. Indeed, many participants proclaimed that too often science courses become a shopping list of facts to be covered. However, only a few participants gave reasons for the dominance of science content in school education. One of the three most repeated reasons was: the attitude of today's students who only want to know what is necessary to pass the final exam and scholarship test. One teacher stated that students develop attitudes such as these from their parents and society in general. The second reason given was the traditional method of teaching science. One teacher indicated that "the content oriented teaching approach is still the most common." Furthermore, through teaching approaches such as these, "students memorize scientific facts, write exams, and then forget the whole thing easily." Another teacher clearly stated that in the government exam, "the processes of investigation, attitudes of scientific endeavor, development of social skills and the relevance of science to the needs of people are not covered or are not covered well." The third most mentioned reason for science content was the competitive pressure on students by the governmental exam.

Because of this, most schools can't afford to address the aims and objectives that require more time and energy to achieve. One teacher, however, made the claim that scientific content is, and will always be, addressed the most, and thus the question is how much, or to what level, the other aims are addressed.

Table 5. 9
Teacher's views of the aims and objectives of teaching science particular ecology (N = 20)

Aims and Objectives	Number of times mentioned	
	Present	Should be
Scientific content.	16	6
Scientific skills/ processes.	9	7
Science and society.	4	8
Nature of science	5	3
Personal growth.	4	8
Science related attitudes.	5	12
Applied science / technology.	2	8
Career opportunities.	5	5
None of them is emphasized	1	-
All of them should be emphasized.	-	1
Neutral/unsure/unclear.	4	2

Some participants justify the dominance of science content by arguing that we need to have some science content in terms of facts, concepts, laws, and skills to start with, at least at the beginning of the course, because everything depends on what you learn earlier. One teacher thought none of the above mentioned aims was getting much emphasis because science in general is no longer considered as important in this society as math and language.

The nature of science, science-related attitudes, and career opportunities were mentioned five times each, as shown in table 5.9. Four participants, however, were neutral and/or gave unclear answers to this question. Thus, we see in this question that scientific content is the primary objective at the secondary school level in lower mainland B.C. today. The three most mentioned reasons [student attitude, traditional teaching methods, and pressure put on students by the governmental exam] are all related to the governmental exam by the respondents. However, scientific content was also defended as a necessary component of school teaching.

Q.8-Which of these aims should be emphasized more in teaching biology and ecology at the secondary school level?

Table 5.9 also provides a summary of the teachers' views as to what aims should be most important. As shown, twelve participants mentioned that developing attitudes appropriate to scientific endeavors was one of the most important aims in science education. Seven of those twelve teachers implied, however, that scientific skills, processes of investigation and content were necessary before a scientific attitude could be developed.

The aims of "Science and society", "Personal growth", and "Applied science and technology", were mentioned eight times each as issues that should be emphasized more in teaching biology and ecology at the secondary school level. Scientific skills and processes, and scientific content were mentioned seven and six times respectively.[1]

Regarding personal growth, for example, one teacher said, "we have to develop a better sense about ourselves as individuals and as part of the society in terms of being able to make necessary changes." Another participant indicated that "it is only by incorporating environmental ethics that we can be assured that things are going to be better sometime in the future."

One teacher thought that regarding applied science and technology, it is important for students to understand, for example, "why some scientists spend their whole life looking at the lifecycle of a particular insect or tree." Students, he added, " should know that information that might be generated from lifecycles such as these might allow

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1 - The role of science and society one teacher thought, was perceived to be good in the 60's and 70's, and everybody really pushed the physics programs sending up a lot of spacecraft into the sky. But, he added, the perception now is that it is too tough to understand this role, so we ignore it. One more teacher said since ecology has political dimensions mixed up with many societal things, science and society is an important aim, "but I see ecology as even broader than that."

biological control as opposed to pesticide control."

In summary, science related attitudes, personal growth, science and society, and applied science and technology, were suggested should be emphasized more in teaching science, particularly ecology. As one teacher puts it, "students will pick up all the other concepts. It is easy to teach science content, but it is harder to do the other parts such as science related attitudes, personal growth, science and society.

Ecology Education Content Research Question

Participants were asked seven question related to ecology education content.

Q.9-What would you like your students to understand ecologically before they graduate from secondary school?

Table 5.10 provides a summary of teachers' views in response to this question. The most common view was having the ecological knowledge necessary for understanding natural ecosystems, interaction, and/or the interdependence of all living organisms and their environment. One teacher included in this, the skills necessary for solving problems and/or gaining fieldwork experience. Understanding our impact on the environment and/or having responsibility for our actions towards each other, natural life systems, and the natural environment came second. "Each person can make a difference and the converse of that is true as well,"one teacher proclaimed. Understanding man's position in the ecosystem came third, as one teacher explained; "He [man] has to live in harmony with the rest of the environment."

Table 5-10
Summary of teachers' views (n=20) of what they would like their students to understand ecologically before they graduate from high school.

No. Teacher's Views	Times mentioned
1. They should be ecologically knowledgeable. and aware and able to appreciate world problems and the natural environment.	17
2. They should be ecologically responsible.	10
3. They should understand and be aware of human's position in the ecosystem.	7
4. They should have a global perspective.	1
5. Neutral.	3

It appears that the majority of the participants would like their students to possess ecological knowledge and awareness, have an appreciation and responsibility towards the environment, and an understanding of their place in the ecosystem. One teacher added, "I want them to develop a slightly more positive attitude toward the effect that they may have on making ecological decisions in the future."

Q.10-What ecological concepts and principles have been taught in biology classes of secondary school?

The respondents mentioned several basic ecological concepts that teachers could utilize in teaching ecology. These were categorized thus: interaction and interdependence of living things(n=10), food chains and webs, trophic levels, ecological pyramids and/or feeding relationships (n=8), energy flows and material cycles (n=7), population, community, and/or biomes (n=6), ecological habitats and niches (n=6), succession and climax (n=3), adaptation to the environment (n=2), etc.

Interestingly, one teacher said that the reason the concepts of interaction and interdependence were emphasized in biology classrooms was because these concepts are well covered in the BSCS, which they used to use. Another teacher claimed that in his school, biology teachers concentrate on man's position in the environment, while most other schools concentrate on the position of animals in the environment. "All schools I know", he asserted, "teach ecological concepts, but they don't relate them to their students as we do."

It seems that, several ecological concepts appeared to be taught in many biology classes, yet all those mentioned could be classified under only one category: the development of ecological background and understanding ecological concepts. It is also clear that the most mentioned ecological concepts are those which do not go beyond the physical aspect of the environment.

Q.11-To what extent do you use various instructional resource materials to teach ecology ?

The most common uses of instructional resource materials in teaching ecology are summarized in table 5.11. As shown, outdoors, textbooks and/or supplementary books and materials, films, and magazines, journals, and/or newspapers respectively, were mentioned as the most common. Materials not shown in the graph were educational TV programs, card games, software computers to do simulations, greenhouses, a salmon project, lab activities, and community members.[1]

Table 5.11
Summary of the most common instructional resource materials teachers used in teaching ecology (n=20)

Teachers' Views	Times mentioned
School grounds and/or field trips.	11
Textbooks, supplementary books and materials.	7
Films.	7
Magazines, journals, and/or newspapers.	5
Video tapes.	4
Slides	2

Fifteen participants said that they used various instructional resource materials and/or "everything that they could," to get the point across in teaching ecology. One, who considered himself an innovative teacher explained:

[1]-Barber and Tomera found that textbooks, films, journals, magazines, and newspapers, were reported first, second, and third as instructional resource materials in teaching ecology by illinois high school biology teachers. Indeed, the data given by B.C. secondary school biology teachers under this question, wasn't in accordance with the Project Synthesis Report (Harms & Yager, 1981) that the textbook is the most used instructional resource in biology classrooms and that biology teachers become more and more classroom-bound.

> I use everything I can to get the point across. I have a series of cards called ENCORE which is a package of cards with student activities, and we do quite a few of those. What I like about them [Encore] is that even though they are designed to focus the student's attention on an ecological concept, or an animal or a plant, the way in which the student records this information is in terms of a poem, a short story, a diagram, or something like that; so it sort of builds bridges between the arts and sciences, and I like that very much! In terms of other means, we use video tapes, "16" mm film, I own some software computers to do simulations; environmental impact, population analysis, etc. So, if it allows me to do what I do more effectively, then I'll use it.

Another teacher added to the above " We used to use the wood plot out here and do ecological breakdowns and study all the relationships and that was good, I thought. We used to have a naturalist come in. The interest was there with the good times, but as soon as the times got harder, jobs became the emphasis." However, one teacher said, "I think the main thing you need is to be able to go outside." Another stated, "the main educational resource, I think, is the teacher's personality." Three teachers were neutral or gave vague answers for this question.

In summary, the participants mentioned field trips and outdoor study as the most important resources for their ecology teaching, although they did not quantify the degree of importance. Textbooks, supplementary materials, films, magazines and journals, newspapers, video tapes and slides were all mentioned to varying degrees, or, to sum it up, "I use everything I can!"

Q.12- How much do you make use of the textbook in your ecology teaching?

The majority of the participants affirmed that they used the text to some degree, yet most of them indicated that the text was, by itself, inadequate in teaching ecology. While two teachers gave no opinion and/or gave unclear answers, two others admitted that they didn't use the text at all, instead they used ecological materials they had developed themselves.

The teachers' answers varied in specificity and used uncomparable terms. Two teachers didn't use the text at all in ecology and another two used it only at the beginning of the course. While some teachers even used the text minimally, four others used it 50% or more of the time. Most typical is the view given by one teacher who said, "It ranges from zero to using the whole first three chapters in the book."

A few teachers tried to compare the new text with the old one (Green Version) - which is ecologically-based, such as one who said "the old book has more ecology than the one which I am using now...[yet] there is never one that is satisfactory. I get a little frustrated having to use six books for Bio 11 over the course of the term." Another teacher stated, "I've never been able to find one at their level that is satisfactory." Still the comments of another teacher who used to use the Green Version supplemented with scientific readings, video tapes , etc, claimed that "the textbook right now, I don't think, has an adequate ecological coverage." One teacher also added that "they [textbooks] are pathetic and weak. They lack just about everything and so does our green version. There is just not a thing in there to challenge."

Even though the majority of the participants in this study asserted that most textbooks are inadequate in teaching ecology with the exception of the Green Version, many teachers still used the textbook to various degrees. A few teachers claimed that they teach from their own ecological materials which they have developed over a period of time.

Q.13 - Do ecological questions get direct or indirect emphasis on both provincial and your evaluation exams?

Table 5. 12
Summary of the teachers' views (n=20) of whether ecological equations get direct or indirect emphasis on both provincial and teacher evaluation exams

	Teachers' Views on the ecology emphasis in the exam				
Kind of exam	Direct	No Emphasis	Not Sure/No answer	Neutral	Total
Provincial Exam.	-	9	3	8	20
Teacher's Exam.	8	-	4	8	20

Table 5.12 provides a summary of the teachers' views on this question. As shown, twelve teachers were neutral, gave vague answers and/or weren't sure, while nine others asserted that there was no ecological emphasis on the provincial exam. The reasons for this according to one teacher "...is because it is not a part of the course...[and it] never has been

in grade 12." Another teacher explained that the lack of such emphasis "doesn't give teachers any opportunity or motivate them to even mention any ecological topics." Another teacher commented, "we are still teaching towards the exam. The large part of the curriculum which we are required to teach in a short time makes it very difficult to find time to include those activities in the core or even in the optional units. The optional unit in the grade 12 curriculum is not ecologically based." On the other hand, eight of the twelve teachers who answered the question stated that they gave ecological questions direct emphasis on their own evaluation exams. The comments of another teacher were, "in the Easter Exam it's [ecological questions] about 25%."

Thus, according to those surveyed, there are virtually no ecological questions on the provincial exam. Many of the teachers forgot to answer the second part of this question, but of those who did, the general comment was, "I include ecological questions every time in my exam."

Q.14- How do you evaluate the ecology section of your general biology textbooks?

Regarding ecology, nine teachers rated the BSCS Green Version as a good and/or better text than the new one because it was ecologically based and 25%-30% of its content was ecology. Four of those nine teachers, however, complained about it. Two teachers indicated that the Green Version was not up-to-date and the other teachers complained that the text lacked controversy, a global perspective and/or environmental issues. Another teacher, on the contrary, answered that the Green Version, which was ecologically a good text, didn't shy away from either ecological or controversial questions. Indeed he added, "it provides very open-ended questions which it gives teachers and pupils a chance to discuss."

Table 5. 13
Summary of teachers' evaluation (n=20) of the ecology section of their general biology textbooks

No. Teacher's Evaluation	Number of The Participants
1. The BSCS Green Version ecologically is a good and/or better text.	9
2. The new text is not good and/or contains only a few ecological materials.	5
3. The new text, with the given supplemental sections is a very good text.	1
4. The new biology 11 course has ecology in every single unit in the core of the course, and there is an optional unit with some up-to date ecology material to go with it.	1
5. Neutral.	4

Regarding ecology in the new biology program, four teachers gave the following comments: "ecology is only one of maybe 5 or 6 sections of the optional unit", "in the one [text] we use in biology it's not very good", "text coverage is minimal at best ", and/or " it's poor". One teacher, however, thought the new text could be good. He said, "the new one, with the given supplemental sections which ties with subjects like aquatic biology, forest management, etc., is a very good text." However, as one teacher summarized", as a text alone, there is not the same emphasis on ecology as in the old one."

Almost half of the participants [9] who answered this question felt that the BSCS Green Version was the best /or better text ecologically than the newer texts. Five others, who did not mention the Green version, said that the new texts are not good ecologically. Only two held other opinions, and four teachers did not answer the question.

Ecology Education Instruction Research Questions

Participants were asked five questions related to ecology instruction.

Q.15- How do you usually teach ecological topics?

The teachers' views as to how they taught ecology varied in specificity and teaching approaches. However, two surprisingly similar, yet opposite approaches, emerged as most prevalent (6 teachers). One approach, as summarized by one respondent, was that, one should "introduce the concepts (lecture), discuss the examples of the concepts and principles, then, if possible, get students out and look for application of those concepts in real life (field)", or "evolution, structure, taxonomy, and field study." The other view was that "one should first go out in the field, or visit sewage plants, etc., and then come in and discuss the issues and concepts, using less lecture time" (5 teachers). For instance, one teacher said "usually, I take students out to the beach and show them some concepts and then we talk about them."

Various methods of instruction, such as group investigation, inquiry methods, debates etc. were mentioned by the participants. One teacher stated that "I don't concentrate on gaining factual knowledge but on understanding of the concepts of ecology. So, I try to give them the opportunity to understand these concepts by discussing issues, formulating ideas, debating opposite points of views, and making decisions on ecological issues and problems."

Two teachers said they integrated ecological concepts throughout their biology course while a few didn't comment on how they teach ecology. Perhaps the most interesting method was that adapted by a teacher who said she used "shock and curiosity."

The following quotations illustrate the typical ecology teaching approaches used by most teachers who answered this question. One teacher said:

> What I tend to do is to start with evolution because all the way throughout the course I'll talk about adaptation and those kinds of things. They need to know something about Darwinism, so I start with that. Then, I look at the structure of the ecosystems such as forest, soil, seashore and study the dynamics of the biome in terms of the food chain, web, pyramid, etc. I finish up with taxonomy. Here, I use the living organisms that already exist in the ecosystem (forest, soil, seashore) and students can actually see, to introduce the concept of taxonomy and why living organisms are classified that way.

Another teacher stated:

> I create a whole bunch of labs and experiments of my own for the population study. We analyse birth rate, death rate, marriage rate, number of kids per family, divorces, separations, and all kinds of other parameters for the district of Coquitlam. Then, we graph all these things and start to interpret them rather than

> talking about how population graphs occur in some other country or on some ideal basis. We talk about sewage treatment and how if you don't have secondary treatment plants in urban society, you are in a lot of trouble.

These two examples summarize how some teachers taught ecology. Overall, moving from concepts to field, or, from evolution to taxonomy, were the most common initial steps, with lab or field to concept a close second. Many methods were used besides lectures, lab work and field trips, such as debates, discussion of issues, group study, formulating ideas, decision-making, etc. Two teachers integrated ecology into the biology course, one used shock and curiosity to motivate students' thinking and interest toward environmental issues, and four didn't say anything about how they teach ecology.

Q.16- To what extent do you use various instructional methods to teach ecology?

As shown in table 5.14, the most commonly mentioned teaching methods were: field study, research, long-term projects and/or a local problem approach, then, the lecture approach, and third, lab activity approach. The discussion and debate approach were also mentioned by a few teachers.

Six teachers felt that they had already answered this question (in the previous question) and thus gave no comment here. Of those who answered, most cited field study and research projects as the most commonly employed instructional methods in teaching ecology. The lecture was designated as the second and lab-activity, third.

Table 5. 14
Summary of the teachers' views (n=20) to what extent they used various instructional methods to teach ecology.

No.	Instructional Method	Times Mentioned
1.	Field study, research, long-term projects, and/or local problem teaching approach.	10
2.	Lecture teaching approach.	6
3.	Lab activity teaching approach.	5
4.	Discussion / debate and/or group investigation approaches.	4
5.	Audio visual and/or illustration teaching approach.	2
6.	Guest speaker approach.	1
8.	Environmental impact assimilated approach.	1
9.	Neutral and/or gave no comment.	6

Q.17- Since teaching models create a certain kind of reality for students, which of these various teaching models are close to your present style of teaching ecology? (A list of some teaching models from Joyce & Weil, (1983) was given to all the participants in this question.

Table 5.15, summarizes of the teachers' response to both this question and the following one. The majority of the participants said that they used a combination of teaching models. For example, one teacher said, "all these teaching models are important ....There is no single teaching technique that can succeed with all the students. It depends on the subjects and grade level you teach." Another teacher explained,"at the beginning of each unit, I lecture or give a presentation, then I move into the development of creative thinking skills and conceptual thought [concept attainment]. Then, I really do a lot of increasing awareness of self and others [awareness training]. When students feel confortable with these, my total teaching really moves easier. If students have a problem in these areas, they cannot go anywhere." Still, the comment of another teacher was, "I have had the best success by approaching the problems from as many different directions as I possibly can. [Students] are in a state of flux at this age. So, flexibility, I think, is the best approach."

As shown in table 5.15, the most commonly used teaching models were: the lecture and BSCS method of inquiry (9-times each), creative thinking (6-times), group investigation, inductive reasoning, and the laboratory method (5-times each), awareness training, synectics, and inquiry training (4-times each).

Interestingly, one teacher expressed the feeling that he is no longer teaching creative thinking because teachers "have to meet the needs and goals of the school which are to crack those scholarship examinations." Another teacher said, "developing creative skills is important, but creativity ranges from thinking to doing....Essentially you can go back to a Socratic dialogue and find a [teaching] model. The only problem is that society may not like the results of teaching students who are both aware of themselves and can ask questions to challenge authority. So, creativity is something that is both desired and a threat." As another teacher observed, "critical thinking brings in the idea of self-awareness, building self-esteem, decision making, choices, and allows you to sort, collect, coordinate and synthesize information, all the things that are very important life skills for any human being."

Table 5. 15
Summary of the teachers' views (n=20) of which of these various teaching models identified by Joyce & Weil (1983) they have experienced in teaching ecology and which of them they wish to experience

Model	Theorist	Basic Focus	Teachers' Views	
			Used It	Wish To Use It
Classroom Meeting	Glasser	Emphasis on self-understanding	2	-
Awareness Training	Schultz & Perlof	Increase awareness of self and others.	4	2
Develop - mental	Piaget, Sigel & Sullivan	Increase general intellectual development, especially reasoning.	1	-
Laboratory Method	National Training Laboratory	Train to cope via encounter-like strategies.	5	3
BSCS	Schwab	Teach modes of inquiry used in academic discipline	9	2
Synectics	Gordon	Develop creative skills.	4	1
Inquiry Training	Suchman	Teach theory building skills.	4	2
Advance Organizer	Ausubel	Increase efficiency of information processing.	3	-
Jurispru - dential	Oliver & Shaver	Evaluate ideas in a judicial-style atmosphere.	1	-
Inductive Reasoning	Taba	Teaching inductive mental processes.	5	-
Social Inquiry	Massialas & Cox	Emphasis on mutual participation in inquiry into the nature of society and its problems.	2	1
Lecture		Group presentation by teacher to students.	9	-
Group Investigation	Thelen & Dewey	Combined emphasis on social skills and academic inquiry.	5	1
Operant Conditioning	Skinner	Share learning using reinforcement schedules.	-	-
Concept Attainment	Bruner	Teach nature of concepts and conceptual thought.	2	3
Creative Thinking	Guilford, Huppert, & Others	Developing creative thinking skills.	6	4

To summarize the teaching models used in ecology instruction, the lecture and the BSCS inquiry method were popular among almost half of the participants.[1] Creative thinking, group investigation, inductive reasoning, and laboratory method were also popular teaching models.

Q.18- Which of these various teaching models would you like to use if you had the opportunity?

As shown in table 5.15, the most preferable teaching models were creative thinking (4 times), concept attainment and laboratory method (3 times, awareness training, BSCS inquiry methods, and inquiry training (2 times each). One teacher, who would like his students to look at the ecological problems in B.C., for example, stated that "I would very much like to get students out and go into the industrial sites and take a look for first hand experience. But again, we are restricted by low funds and other kinds of restrictions. If I had the time and funding, I would like to go to inquiry bases."

Nine teachers, however, were neutral and thus did not select any of the given teaching models. Interestingly, one teacher said, "if I have the opportunity I would like to work on product process information, such as where to find information, or how to make up questions and deal with them." He added, " if I have my way, I would have kids make film strips, interview scientists, etc." Another teacher, who seemed to agree, said, " It would be nice to have a bank of wonderful ideas and models to draw from. They are hard to come up with, but when you get them, they are wonderful to use."

In summary, only a few teachers referred to the kind of teaching models they would like to use if they had the opportunity. Of all those models, creative thinking, concept attainment and laboratory method, in that order, were the most common. The majority of teachers did not select, or gave no comment.

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[1]- This, however, is understandable since there is clear evidence that most teachers in North America lecture over 70 % of the time, and BSCS Green Version had been in use in B.C. Canada for more than a decade.

Q.19- Which of these reasons prevents you from teaching ecology effectively and why? (A list of seven reasons selected from the literature was given to each teacher).

Table 5.16 summarizes the views of the interviewed teachers as to what prevents them from teaching ecology effectively in secondary school biology.

Table 5.16
Teachers' views of what prevents secondary school biology teachers from teaching ecology effectively

No. Reasons / Factors	Number of Participants					
	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Total
The nature of ecology	7	1	2	-	10	20
Confusion about how to teach ecology.	6	5	-	1	8	20
Lack of appropriate samples of examination syllabuses and papers.	7	1	1	2	9	20
Lack of teacher confidence in dealing with ecological issues and in identifying local flora and fauna.	12	3	-	-	5	20
A shortage of appropriate facilities and inexpensive equipment.	3	-	2	1	14	20
A perceived dichotomy between practical and theoretical ecology.	10	2	3	-	5	20
Lack of emphasis on observation in science education.	3	1	10	-	6	20

The nature of the subject

As shown in the table 5.16, the participants were almost equally divided about the difficult nature of the subject. Seven teachers agreed and another teacher mildly agreed that the difficult nature of ecology contributes to the problem of effectively teaching it. Ten teachers disagreed. The two remaining teachers were neutral and/or answered the question vaguely.

The ten teachers who did not think the nature of ecology was a problem gave the following reasons. "I have a great concern about ecology and so I don't find the nature of ecology a problem." "I like ecology and being outdoors." "The problem is not the nature of the subject, but lack of awareness by teachers of the nature of the subject." "First, the problem is the educational system...[which]...doesn't allow for time necessary to take students into the field...[and] lacks in many cases the flexibility. I think, first, the system itself is not good for teaching ecology effectively." "We concentrate on it and we are doing it very well, in general, I don't think this can be a problem for a good biology teacher." "The people in our department are all really intelligent,...comfortable with all sorts of things, like ecology, changes, and doing something different."

The eight teachers who thought the nature of ecology was difficult and that it could thus prevent them and/or other teachers from teaching ecology effectively generally spoke about teachers who hadn't been exposed to ecological practice or theory. They referred to a lack of experience in undergraduate studies and/or a lack of training in teaching ecology in their pre-service education. They also were speaking in terms of going out and spending time in the field. For example, one teacher said, "...the nature of the subject is a little bit ambiguous because ecology is difficult to do in the classroom. So, you have to go out and experience some of its concepts. Go out and live in or walk around the environment to fully understand because some of these concepts are very difficult to grasp."

It seems that none of the teachers thought of the nature of ecology as a problem, until asked about the nature of ecology. Their reasons were very closely tied to the nature of the educational system, time-clock, funding, etc. or of the teacher's experience in ecology, rather than to the nature of ecology itself.

Difficulties and confusion in teaching

Regarding the difficulties and confusion in teaching ecology, table 5.16 shows that six participants agreed and five others partially agreed that they and/or other teachers did encounter some problems. On the other hand, eight teachers disagreed and one teacher partially disagreed that they had any difficulties in effectively teaching ecology.

Generally speaking, the eleven teachers who thought teachers faced difficulties thought that the problem stemmed from insufficient ecological background (7 teachers) and/or an outdated teaching style (8 teachers). For example, one teacher said, "I think to study ecology teachers have to do field work. They have to be able to spend a lot of time discussing principles with students and that means a lot of student involvement. And I know a lot of teachers are not comfortable in teaching using this style, so I think that can be a major problem." Another teacher claimed that he knew some teachers who teach ecology straight from the textbook and through a lecture approach. He added"they never do field work, so this can be a problem." However, one teacher blamed the educational system rather than the teachers or the difficulties inherent in teaching ecology. He said "Secondary school teachers themselves are victims of the system. They do not have the time, opportunities or facilities to really teach the students outside the abstract classroom situation."

On the other hand, as shown in table 5.16, a total of nine teachers disagreed that they had difficulties or confusion about how to effectively teach ecology. One of the teachers, for example, believed that it wasn't difficult or confusing to teach it at all. He explained "we are not teaching it at a difficult level. We teach it at the lower level of understanding. It can be taught at grade eight. Students age 17 and 18 think about matters in a different way. They look at things more globally and they realize the significance of things." Another teacher said,

> Ecology is a very difficult subject to teach because you have to be a jack-of-all trades. You have to have the earth science background, the chemistry background, biological concepts, physics principles, etc. If you do have people with this kind of background where they can synthesize, or can bring things together and apply this discipline with that discipline and pull things out of their hat for example, well, this is beautiful. If they cannot, well, then there is always classical ecology, and the students come through.

Lack of appropriate samples of examination syllabuses and papers.

As shown in table 5.16, nine teachers did not think that lack of appropriate samples of examination syllabuses and papers had anything to do with preventing them from effectively teaching ecology. Two more teachers were in partial agreement with these nine. On the other hand, seven teachers asserted that lack of appropriate samples of examination syllabuses could prevent them from teaching ecology effectively, while one more teacher mildly agreed. Only one teacher was neutral. Generally speaking, only a few reasons were given by participants (both those who agreed and who disagreed) to justify their answers in regard to this question.

The reasons given by those eight teachers who indicated that lack of examination syllabuses was a problem varied from "examination only reflects the reality of the teaching methods which the traditional teaching style," to "lack of specific ecology courses in school curricula." to "a lot of ecology subjects are optional." To cite but a few of the answers of those participants, one teacher revealed that he thought examinations tend to promote teaching by traditional methods -- by lecture, by textbook, by worksheet and so on -- while he didn't think that was the best way for students to understand ecological problems. He said "students have to be able to discuss, give ideas, debate opposite points of view on ecological problems, so I think that having final exams that are based on content can create problems. I don't think it has to, but I think it does." The comments of another teacher were, "Too much emphasis is placed on the true/false examinations which do not test understanding, but only their ability to regurgitate a set of facts or certain information." Still another teacher thought, "the easiest questions to put in the exam are multiple choice. But that is not the sort of thing that promotes understanding of the concepts of ecology. It is great for factual things, but much of ecology is not just facts. If you have to learn the names of every plant and animal running out in the forest, then you can use multiple choice tests, but that is not learning anything about ecology."

Those teachers who did not believe that there was a problem in the lack of appropriate samples of examination syllabuses included:"textbooks were written to promote teachers to teach ecology inside the classroom", "the governmental exam has forced teachers to give up on going outside","ecology isn't different from biology" and " there is no final exam in bio.11, and so, there is no limitation on the teachers."

One teacher felt that ecology, which is an important part of biology, isn't different from biology and that, "if you have done biology without ecology, that means you have not done the most important part of biology." Still another teacher, who couldn't see how this could be a problem said, "I think if teachers know how to teach biology and how to evaluate student understanding and achievement in biology 11, then they should be able to do so in ecology topics as well."

Lack of teacher confidence in dealing with ecological issues and in identifying organisms

As shown in table 5.16, fifteen teachers generally agreed that they lack confidence in teaching ecology and this contributed to ineffectiveness. They indicated that lack of confidence stemmed from lack of sufficient background and experience (4 teachers), insufficient education (6 teachers), the urge to know everything and/or always be right in front of their students (2 teachers), and the difficult nature of the subject and how to teach it effectively (3 teachers).

One said, "teachers really lack confidence. That is really true. They don't know what moss is, they don't know what biological decomposition means, and they really get frustrated when they get out there and the kid says 'well where are all these small animals you talked about? Why aren't they there?' And they just say 'what the heck, this is the last time I'll do this! I'm not going out there if the animals are not going to cooperate', and that's what happens." Another teacher explained, "Teachers lack confidence sometimes because they themselves have been educated in the system which does not give them the needed training in biology and ecology. It used to be that people knew the names of the plants and animals surrounding them whether they are scientific or local names. They knew the use of these plants. We now no longer have a society that presumes scale of task for ecological education. So, in that sense, there is a lack of confidence in identifying organisms." Still another teacher who believed that lack of confidence is one of the main things in ineffective ecology education said, "This goes along with insufficient teacher education in teaching ecology. I don't think this is because of the universities, but because the teachers are not concentrating on that aspect of biology...In the 60's and the 70's, we had a big push to do ecology and we did that. Now people have moved back to the tradition." One more teacher indicated that, "lack of confidence is probably the problem many teachers have. Teachers should be aware of themselves and if they have this problem, they should be willing to do something about it."

Five teachers, on the other hand said, that they did not lack confidence in dealing with ecological issues, or in identifying local flora and fauna. One teacher appeared to think that lack of confidence was a poor excuse, because good educators can jump boundaries. He said, "when you take kids out, kids expect you to know what they [flora and fauna] are called and I don't worry about it too much....I suppose people who feel that teachers always have to be right or always have to know, are insecure about this kind of thing. But, you know, you are examining eco-systems and the dynamics are very difficult to understand. So, I like getting involved with kids in situations where you are trying to describe the eco-system or determine how the eco-system operates and that's a sharing thing." Further he added, "the interesting thing is that an awful lot of people who are old-fashioned biology teachers (the classical style) have a tremendous information base and probably know more than this. It's just that they get in a situation where they might find something that they don't know and they get nervous." The comments of another teacher were, "We are six teachers here and I am not aware of lack of confidence in any one. We all teach it. We all spend 20-25 % of our biology course doing nothing but ecology. Then, we don't leave it, but carry it as a theme throughout the rest of the material. One more teacher proclaimed that, "Lack of confidence can be a problem for many teachers in general."

One very interesting comment of how teachers develop self confidence was the following:

> Just to set an example I once had a lady come from Ontario to visit the school that I worked at. And we went out and we were going to do an ecological study that day and she said "Okay, well, what equipment do you want to bring?" And I said, "Oh, well, we'll bring a powerful hand-reading glass for every 2 kids and we'll bring a pair of binoculars for every other 2 and we are going to go for a walk." And as we went for a walk I found a dead salmon so we dissected the salmon and identified it as to sex and then we looked at the rocks around it and we talked about why the volcanic rocks were in the river bed and then we talked about stream erosion and we talked about what happens when a stream wears out a patch and we start to see alder trees growing. We talked about how alder trees reproduced. We found eagles. We found blue birds. We found a river otter. And we did it all and at the end she went, Hey, that's amazing; How can you do that? And I said How can you go out in the field and <u>not</u> do that?" And she said "But you know all of those things. And I said Well, no, I don't. Every time I go I find something new and in my pack sack I keep my bird book and I teach kids that they shouldn't be afraid to try it. I really like to impress upon kids and I took great pride in showing kids that I learn something new every time I go out. And so I think that that's the number one[problem] -- a lot of teachers who want to know everything before they try it.

Then he added, "I would say that what teachers need is to be introduced to their own abilities to communicate with people because one of their fundamental roles is to be communicators."

<u>A Shortage of appropriate facilities.</u>

As shown in table 5.16, the majority of the participants (15 teachers) disagreed that the shortage of appropriate facilities contributes to ineffective teaching. Five of those teachers thought lack of equipment is only an excuse for people who don't like to teach ecology, or to venture outside the classroom, and/or don't know how to teach ecology. One teacher, for example, who believed that the outdoors was the facility, said, "Even an inner city school can do ecological problems just by going outside into the school grounds, by looking at the environment, the urban environment around the school...so I don't think lack of facilities should be an excuse, but I think there would be people who would use that excuse, 'I can't do it because', I think it's a lot easier to say I can't do it than to go out and do it." He added, for example, "If the teacher perceives that it's important to cover a certain amount of content by a certain amount of time then perhaps that teacher would say there's not enough time to do ecology, but I don't think that's necessarily a real problem. It's a perceived problem by teachers and is a very general perceived problem. I think in many cases it's just an excuse to teach in the easiest way of teaching which is textbook teaching." Another teacher thought, "I don't think we lack facilities. Microscopes are all you need. You can make a lot of the equipment, but because of the negativeness of teachers,...[and their depression] over the economy, they say, to hell with it. I'm not going to make anymore of these things. I'm going to leave, go home early, and I think that's a problem." However, this person thought what is needed is some approaches to ecology that help teachers teach. The comments of another teacher were "Equipment is still in line, everything is still there, you just need to get the confidence to do it. I think teachers still have the attitude of the 60's and 70's, but the attitude of society has changed. They want to get away from that and do conservative things. They want more immediate goals while ecology is out there for long term goals and they couldn't identify it, so, they dropped it. Now, I believe, it's started to come back a little bit. You are going to see more of these things coming again and teachers will pick up ecology again."[1]

Only three teachers, on the contrary, stated that there is a shortage of appropriate equipment necessary for effectively teaching ecology. For example, the comments of one teacher were, "Yes, there is a lack of facilities. There hasn't been that much stuff available

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[1]- One teacher who didn't see equipment as a problem, justified using simple equipment in teaching by saying that " I tend to use simple equipment in ecology from the point of view that I don't want kids to feel mystified by the manipulation of the equipment in order to study the subject. I work very hard to make science easy and to relate science to students' daily lives. I teach most of my biology in the field by having them draw pictures or take photographs. "

for it. You had to do it mainly yourself. I mean there is a little bit in the Bio 11 textbook that we have right now." Another teacher said that because there is not enough money around and ecology is not a major part of the science program, most of the equipment is shuffled away from ecology. Thus lack of facilities in teaching ecology is a real porblem.

One teacher, however, viewed the problem of equipment from a different perspective. He claimed that, "It is always a problem. I don't think there will be enough facilities in the schools unless society develops a different perspective on school and the education system."

A perceived dichotomy between practical and theoretical aspects of ecology

As shown in table 5.16, twelve teachers agreed that a perceived dichotomy between practical and theoretical ecology does exist and affect the teaching of ecology. According to the twelve the dichotomy arises because many teachers concentrate on the abstract rather than the practical. While one teacher, for example, asserted that it was hard for students to understand the nature of ecology without the combination of both its theoretical and practical aspects, another teacher stated that, "Practical courses either are not available, or are not sufficient in their effect." Agreeing with this, another teacher said,"this might be because of the nature of the educational system and grading system." However, another teacher stated unless you go out and do ecology, teaching ecology will be seen as difficult. Five teachers, on the other hand, did not perceive a dichotomy between practical and theoretical ecology, and therefore did not see it as a problem in teaching. If it is a problem, it is not just with ecology explained one teacher, but with all science courses and teaching, and that is why students have problems with school in general. Further he said: "They [kids] just can't see what the devil all that we are teaching them has to do with the real world or how it deals with them! Ecology can be made, as with any science and with any course, more closely applied to home. This, of course, depends on the skill of the teacher and the person that is writing the book and the syllabus."

Another teacher, who took ecology at the University of British Colombia, said that the theoretical notions which he studied were saturated with complex statistical data, graphs, diagrams, etc. He stated that "people have different views about what ecology is and, as you know, it's a very rigorous discipline. Now, when a guy says that theoretical and practical ecology are divorced, maybe it's being divorced because nobody is really making it clear enough for the teacher who hasn't got the background to use some of those ideas."

Lack of emphasis on observation in science education and particularly in teaching ecology

It is interesting to note, as shown in table 5.16 that ten teachers were neutral and/or not specific in their answers to this question. However, while six participants did not think that insufficient emphasis on observation in science education in general contributes to the ineffectiveness of teaching ecology, four teachers thought otherwise.

For example, one of those teachers who agreed said, "Most teachers have not been trained to teach observation, so they may not know how to teach." Another teacher thought that"...up to this point, there' ve always been 480 questions along with the lab. When does the student get to really free-wheel about what he/she is really seeing, because it often ends up, 'all right, the experiment is over, write it up and hand it in, and make sure these 8 questions are finished.' Now where in that model is there room to do what you have just suggested? There's got to be more openness, less questions, less structure. There should be a flexibility in our educational system." Still another teacher observed:

> It depends on the teachers. You can stimulate observation in the students even by asking them to observe themselves or each other. If teachers don't emphasize observation in front of their students, then it is unrealistic to expect them to do it on their own. I always give my students an observation assignment when they go out. I always tell them that this field trip is not only a social event but also for educational experiences and learning. So it is a teacher job. For example most students neglect the lab-work processes and in many cases turn the lab into a social event.

On the other hand, six teachers disagreed that observation was not sufficiently emphasized. Only two of those six teachers, however gave an explanation for their answers. For example, one of them said, "Well, I would disagree. I don't think we address it as a specific topic. I think it is maybe not formalized or people do pay a lot of lip-service to it...[but] you think of the dissections you do in Bio 12 or Bio 11, what skill is dominant there? It's observation. I really disagree that it's not being done, it's just not natural in my mind." Another teacher outlined his simple method of teaching observation:

> I would say, in my style of teaching no. All you need is your eyes. A hand lens really helps and a pair of binoculars. And if you walk quietly you can see and hear a 100,000 different things any day on any trip. It's just a matter of learning to look. I used to do a little thing where I'd walk through the bush. I'd go for 20 minutes and I'd say alright now let's make a list of all the things we've seen while they poked and pushed and pulled. I counted out 10 different trees I'd seen, 5 kinds of wildflowers, 4 kinds of mushrooms, the snake..."Did anybody see the snake. No we missed the snake. What about the frog. No we missed the frog. What about the raccoon tracks. No we missed the raccoon tracks. Well, how can we do this. How can I do it? Well you are the teacher. I said No, I simply looked where I went. Then the next 10 minutes I ask the same questions and all of a sudden every kid has seen something different, so if you've got 30 kids you've seen 30 things. And so from that point of view I have always taught observation.

It is interesting, however, to note that five of the seven teachers who gave an explanation to their answers stated directly or indirectly that developing observation skills among students is a teacher's job. For example, one teacher thought, "Teaching students how to make observations and how to process their data depends entirely on the teachers themselves who are supposed to be good observers." Another teacher said "If you want to develop observation skills and processes in students so they can observe in an ecological sense, you have to have a more flexible time table content to get out and spend time outside without having to come in in 45 minutes. This is very detrimental to developing observation skills. Second, you have to have a personal commitment to make that important part of curriculum to teach observation. This might not be part of the curriculum."

Other Reasons That Might Prevent Effective Ecology Teaching

Teachers pointed to three potential problem areas which might prevent teachers from effectively teaching ecology, and which were not addressed in the literature review of this study. Those problems were: (1) Insufficient teacher education (pre-service and in-service) in teaching ecology; (2) The nature of the present educational system; (3) The absence of ecology in the core section of the curriculum or as a compulsory topic.

<u>Insufficient teacher education (pre-service and in-service) in teaching ecology</u>

Ten of the fifteen participants argued that ecology education for teachers doesn't exist. Two teachers weren't sure and three thought it was rare and/or without follow up, or only existed at the elementary school level as ecology workshops. One teacher thought, that even if inservice ecology education exists, teachers usually do not attend because they are overworked and there is not sufficient money available to pay for it.

To quote one of the respondents who didn't want to learn content but process in inservice education:

> There is none in ecology. But there are a lot of things you can take outside of the school district which are not in inservice education in the district. A lot of the in-service education programs teach concepts teachers already have. They should concentrate on what they can give teachers to put in their curriculum. Teachers themselves know most of the ecological concepts, but what they need is what they can do in the classroom to teach a particular ecology subject. They also need papers, materials and other things. They need very detailed things about how to teach concepts and how to integrate some concepts into their curriculum and a lot of teachers need that.

In sum, most of the teachers claimed that there is either no inservice or preservice education, or that what there is, is insufficient and ineffective. They also expressed the view that teacher ecology education is important, especially for those teaching biology or ecology with no background in either of those areas.

The nature of the present educational system.

Five participants mentioned twelve times (directly or indirectly) the problems involving the nature of the educational system. Those participants asserted that the present educational system is not conducive to effective ecology teaching because it does not provide the flexibility or the time necessary for field work, long-term projects, research and investigation, or lab work. Most participants felt that many teachers aim toward the governmental and scholarship exams, and that that focus hinders their teaching.

The absence of ecology in the core section of the curriculum and as a compulsory topic.

Some of the respondents claimed that because ecology is not a core or compulsory topic, it is not being taught. They said that in the old biology curriculum, ecology comprised 20%-30% of the core, and even then many teachers omitted it in their teaching. So now, when it is an optional unit, it is not getting the attention it merits, even if teachers want to teach it.

Discussion

In 1979, Booth identified the following reasons as factors that might prevent effective ecology teaching: the nature of the subject, confusion about how to teach it, lack of appropriate samples of examination syllabuses, lack of teacher confidence in teaching the subject, and a shortage of appropriate facilities. The gap between the practical and theoretical, as well as the lack of emphasis on observation in science education have been perceived as additional factors by others (e.g. Wells, 1982; Norris, 1985).

Data analysis shows that the secondary school biology teachers in the Lower Mainland in British Columbia who participated in this study were almost equally divided (with +_3) on the effect of the nature of the subject, difficulties and confusion about how to teach ecology, and the lack of appropriate samples of examination syllabuses and papers. In this study no correlation was found with these three particular observations from Booth's study. A further study, therefore, is needed if a relationship is to be established.

The majority of the participants, on the other hand, appeared to agree with Booth's study regarding the lack of teacher confidence in teaching ecology and in identifying local flora and fauna (15 agreed/5 disagreed). They did not see, however, the shortage of appropriate facilities and equipment (15 disagreed/3 agreed) as a problem. The majority of the participants also perceived dichotomy between practical and theoretical aspects of ecology in teaching as one of the main factors that might prevent secondary school teachers from teaching ecology effectively. Regarding the lack of emphasis on observation in science education in general, and ecology in particular, half of the participants (10 teachers) seemed unaware of its effect on teaching ecology. Yet, they were almost equally divided (4 agreed/6 disagreed) on whether to perceive it as a problem.

The biology teachers who participated in this study provided additional reasons that might prevent secondary school biology teachers from teaching ecology effectively: 1) insufficient teacher education (pre-service and in-service) in teaching ecology; 2) the nature of the present educational system; and 3) the absence of ecology in the core section of the curriculum or as a compulsory topic. Indeed, all the reasons identified by Booth (1979) and others (e.g., Ham& Sewing, 1987/88; Uma, 1988) seem to stem from these three additional reasons provided by the participants.

Rather than the seven reasons in table 5.16, it might be the three reasons which were provided by the participants in this study which seem most significant in relation to understanding problems in teaching ecology. It is obvious that the lack of sufficient teacher education will lead to unqualified teachers, not only in the teaching of a given subject but also in developing teaching aids and curriculum materials necessary for effective ecology teaching. It should be understood, however, that exposing biology teachers to ecology only in their pre-service education is not enough to gain and maintain confidence and professional growth in teaching ecology without ongoing inservice ecology education and visa versa. Inservice ecology education is needed to increase teacher confidence and to develop professional interested growth. If formal teacher education courses in ecology exist, however, then teacher comments could reflect the general lack of participation by them. Biology teachers must be motivated and exposed to ecology and how to teach it in both preservice and inservice education.

In addition to teaching ecology, the absence of ecology in the core section of the curriculum and as a compulsory topic potentially results in schooling where only environmentally oriented teachers integrate ecology into their biology courses, or select ecology as an optional part of the curriculum if there is enough time. Related to this is the absence of ecological questions in the provincial exam for secondary school science students. As both Eichler (1977) and Booth (1979) pointed out, unless ecological questions are integrated in student exams, it is unlikely that attention will be given to the subject. Yet, including ecology in the final exams is not enough without teaching ecology effectively. Booth suggests that teaching ecology should be based on "a foundation of extensive and rigorous 'nature study'"[1] through which students learn how to look at nature and to ask questions about it. In doing this ,students should be involved in experimental and practical work, using their senses and looking into situations rather than reading about them. This might be achieved if ecology is taught through the integration of classroom, field, and laboratory situations (Hale,1986b) with an emphasis on the structure and function of ecological systems and through the process of ecological inquiry (Cox, 1970) and problem-solving (Bybee, 1979c; 1984).

Ecology and/or environmental study, whether as a discipline or a subject, is a new branch of knowledge in the present educational system. While ecology by its nature is a holistic, multi-disciplinary, and field-oriented study that requires a diverse approach, the present educational system, with its time-limited-class system is not suitable for teaching ecology and environmental study specially when only a few school administrators

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[1] Since there can be no substitute for real things, Dowdeswell and Potter (1975) see that " Ideally, all ecology courses should be based on natural habitats." (p. 248). Hale (1986) however, sees that ecology can be taught effectively by using urban environment.

understand the special needs of the science teaching and ecological oriented programs for double periods and/or additional funds (cf. Hufford, 1989).

In conclusion, secondary school biology teachers who participated in this study speak of the ineffectiveness of ecology teaching in many biology classes and the reasons for its ineffectiveness. While they recognize the importance of teacher confidence in teaching ecology and securing a balance between practical and theoretical aspects of ecology, they pointed out major obstacles to effective teaching . These obstacles include lack of training or professional development in teaching ecology, the philosophy and structure of the present educational system, especially in terms of flexibility and available time, and the absence of ecology topics in the core curriculum, especially in the presence of the tremendous pressure exerted from the governmental exam and, to some extent, the scholarship exams.

Further studies should be conducted 1) to examine the findings of this study on a larger scale in terms of space, participants, and school level, 2) to examine the relationship between teacher education and the effectiveness of teaching ecology, and 3) to examine the relationship between the present educational system and the effectiveness of ecology education.

Further studies should be conducted 1) to examine the findings of this study on a larger scale in terms of space, participants, and school level, 2) to examine the relationship between teacher education and the effectiveness of teaching ecology, and 3) to examine the relationship between the present educational system and the nature of ecology education.

General Research Questions

Participants were asked the following general research questions.

IQ20- Is there any inservice education regarding ecology teaching based on your knowledge? If so, how effective was it and how many courses or workshops did you attend?

As shown in table 5.17, the majority of the participants (12 teachers) claimed that there was no inservice ecology education provided by school districts in B.C. Canada for the secondary school level as far as they knew. Two of those teachers said there used to be, but was no longer. Five other teachers, however, indicated otherwise, even though one of those five asserted that what little there was was neither enough nor effective. Two of them indicated that they had themselves designed and given some inservice ecology education workshops. Yet, the opinions of those five teachers varied regarding the effectiveness of in-service ecology education. Three teachers asserted that it was not effective. Another teacher claimed that it was hard to measure the effectiveness of those in-service programs, and yet, another teacher didn't give any opinion on the effectiveness.

Table 5. 17
Summary of the teachers' views of the existence of inservice ecology education at the secondary school level (n=20)

Exists	Rare	None-existent	Don't know/Neutral Total	
4	1	12	3	20

Only one of those five participants who believed that there was in-service ecology education, thought it was effective, as shown in table 5.18.

Table 5. 18
Teachers' views of the effectiveness of in-service ecology education at the secondary school level (n=5)

Effective	Not effective	Don't know	Total
1	3	1	5

Q.21- If you had the opportunity to attend in-service ecology education workshops would you like to? How many hours do you think per year would be useful for teachers to gain and maintain effectiveness in teaching ecology?

As shown in the table 5.19, the majority of the participants who answered this question (11 teachers) would like to attend in-service ecology education workshops, given the opportunity. Only two teachers indicated that in-service education is for teachers who need it. As one teacher put it, "we often get teachers who haven't had any background in ecology and they are the ones, I guess, who would need some in-service. Especially, I would think, junior high school teachers who perhaps have a background in physics or chemistry and no ecology background at all and they end up teaching junior high school science which covers the whole spectrum of science." Another teacher commented, "I think I wouldn't because my background is very solid, unless there would be new topics. If it is in a general environmental education or ecology, I don't think that is what I need."

Table 5.19
Summary of the teachers' views of whether they would like to attend in-service ecology education or not (N=20)

Will Attend	I Will Not Attend	No Comment on the First Part of the Question	Neutral/No Comment	Total
11	2	3	4	20

As shown in the table above (5.19), four teachers were neutral and/or gave no comment on the entire question, and three more teachers gave no comment on the first part of the question (attendance).

Only nine teachers, as shown in table 5.20, commented on the number of hours of in-service per year needed to gain and maintain effectiveness in teaching ecology. Those teachers varied in their opinion as to how many hours would be needed, from half a day to a whole day workshop, to short weekend, night courses, and finally to a week long workshop per year. One teacher suggested that inservice ecology education should be an ongoing process and stated that school districts should provide time for teachers to attend, and should also pay for it.

A few teachers provided details as to what teachers really need in inservice ecology education. For example, "It would be great if we had some current inservice courses and I would attend them because science is changing so fast and especially our knowledge in ecology. We have to have current applications and the new facts. It's changing daily, so in-service education would be invaluable." Another teacher suggested that "In in-service ecology education, teachers should learn new subject matter, experience different teaching techniques, develop enthusiasm, extend social content and contact, and prepare for new teaching assignments."[1]

Table 5. 20
The number of participants who commented on how many hours they think would be useful to gain and maintain effectiveness in teaching ecology (N=20)

Teachers commenting on this part of the question	Teachers who didn't comment on this part of the question	Neutral/No comment	Total
9	7	4	20

Q.22- What kind of advice would you give to teachers who have to teach ecology at the secondary school level?

All the participants commented on this question, although their recommendations varied. The most common recommendations were:

1. Teachers must have sufficient knowledge and adequate understanding of ecological concepts and principles. They should also be able to teach ecology and have the commitment to do so.

2. Teachers should live an ecologically sound life-style, otherwise what they say to our kids will not have any substance.

1 - One teacher. who was tired of seeing High School Multi-Ecology Courses [in U.S.A.], preferred to see scientists presenting practicable science that he might be able to use. Another teacher, who complained that teachers have a far higher teaching load than professors in the university, said "since we [teachers] don't have the time or the access to literature that university professors have...I think they [professors] have a responsibility to provide some updated new mini-material for me."

3. They should communicate to students the basic understanding of what a sound environment is. This means going beyond teaching abstract ecological knowledge. It also means having ecological understanding and the ability to implement the knowledge in different ways.

4. Teachers should be willing to spend a lot of time in practical "hands-on-experience"with their students and not just teach ecology theoretically from the text. In other words, students should be taken out of the school and into the environment, so they can experience the basic concepts of ecology for themselves.

5. Teachers should also provide field trips and hands-on-experiences that require the participation of the students, parents, and teachers. In experiences such as these, all participants spend time learning about nature and each one of them contributes with what he/she learns and understands from the whole group.

6. Teachers must be aware of the short and long-term goals of science education in general and ecology in particular, and they must select educational topics based on these goals.

7. They must integrate ecology into the rest of the curriculum. In other words, ecology should be incorporated throughout the biology course and interspersed throughout the year. The Green Version of the BSCS approach, which integrates ecology throughout the whole course, is an excellent example.

8. Teachers must spend a significant amount of time on debates and discussions, as well as doing group investigations on ecological issues and problems. They also should give students an opportunity to see both sides of a given issue, such as the use of pesticides, nuclear energy, etc.

9. Teachers must concentrate on developing the following kind of attitude among students:

a) We are newcomers here. We came along much later than many other creatures on this planet.

b) We must fit harmoniously into the ecosystems of this planet rather than be the dominant species.

c) We must develop among school children the personal commitment of making the world a better place. The children of the future must be left something better than what is here now.

10).Teachers must take ecology courses and attend workshops if they do not have the background to approach ecology from field experience.

A good example of the comments teachers gave to this question was given by one teacher by saying:

> Get away from your textbooks, get outside and start doing things. Our own limitation is ourselves. If you want to do things, you can. The problem is we build all these walls before we get started, we never even try to break the wall. But there are a lot of things to do in ecology. It is unbelievable, and there's a lot of fun, like the trip we did to a tropical rain forest. It is the matter of doing it. The only limitation is yourself. We are all looking for excuses; it is the person himself. If you want to do it you can!

CHAPTER SIX

SUMMARY AND FINDINGS - II

Teaching Observation and Biology textbooks and Curriculum Guide Analysis

This chapter deals with teaching observation and biology textbooks and the Bio 11 & 12 curriculum guide analysis, and provides answer for the question of what the nature of ecology is in Lower Mainland British Columbia today and how it is being taught.

An Analysis of the Biology 11 & 12 Curriculum Guide

The justification for analysing the curriculum guide is that it provides the skeleton for content, teaching strategies, and other material that the teacher brings into the classroom.

General Description of the Biology 11 & 12 Curriculum Guide

The 1986 B.C. curriculum guide for the Biology 11&12 Program identifies the rationale (why teach biology), philosophy (what is biology and how should it be taught), goals (what school biology should achieve), scope, and sequence of the course and describes its design. The "order in which the various topics are addressed, and the teaching methods used, are left to the professional judgement of teachers" (p.7).

The rationale for Biology 11 & 12 focuses on the development of individual abilities, (1) to reason logically and independently and make social, economic and political choices based on an understanding of the world; (2) to deal with a wide range of human concerns; (3) to enter the work world and possible academic career; and (4) to understand science not only as a particular kind of human endeavor, but also to understand the limitations of its application. The philosophy of the Biology 11 & 12 program deals with what biology is and how it should be taught. According to the curriculum guide, biology is "the study of living organisms and life processes. As a scientific discipline, biology is also defined by its methods of inquiry, and characterized by the social context in which biological research is done and biotechnology is used" (p. 3). The goals of the Biology 11 & 12 program are to develop biological knowledge, learn the processes of science, scientific attitudes, and critical as well as abstract thinking abilities.

Table 6.1 which shows the components of the current Biology 11 Program consists of four core areas and twenty optional topics. The four core areas (as shown in appendix 6.3) are: Methods & Principles, Microbiology, Plant Biology, and Animal Biology. The twenty optional topics of the Biology 11 Program from which two or three topics should be chosen per year (as shown in appendix 6.3) are: Microscope, Mycology, Bryophytes, Ferns, Invertebrates, Parasitology, Vertebrates, Fisheries Biology, Wildlife Biology, Freshwater Biology, Population & Community Ecology, Animal Behaviour, Evolution & The Fossil Record, Genetics, Silviculture, Bioethics, Careers in Biology, Population Genetics, Terrestrial Habitats, Intertidal Marine Biology, and Aquaculture.1

Table 6.1
Summary and comparison of the components of Bio 11&12 programs

Curriculum Component	Biology 11 Program	Biology 12 Program
Goals	4	4
Core Areas	4	4
Core Topics	16	13
Core Hours Needed	70	80
Optional Topics	20	7
Option Hours Needed	30	20
Core Learning Outcomes	138	189
Core Lab.	60	43
Option Learning Outcomes	272	100
Option Lab.	63	6

The current Biology 12 Program has four major core areas but only seven optional topics as shown in table 6.1.[2] The four core areas (as shown in appendix 6.4) are:

1- Even though ecological principles and concepts can be introduced in the teaching of most of these topics the willingness to teach ecology depends entirely on the background of the teachers and their willingness to emphasize them (cf. McClaren, 1987)..

2- Teachers who have an ecological background and an interst in teaching ecology will be able to integrate and/or introduce ecological principles and concepts into the three following optional topics of Biology 12: Plant Development & Control, Cancer, and Genetic Disorders & Engineering.

Methods and Principles (5 hrs), Cell biology (20 hrs), Plant Biology (15 hrs), and Human Biology (40 hrs). The optional part of the Biology 12 program (as shown in appendix 6.4) contains seven possible topics that teachers must select to total 20 hours of material. This means that teachers have to select two optional topics. The optional topics are : Immunology, Skeletal System & Muscles, Reproduction & Embryology, Genetic Disorders & Engineering, Cancer, Plant Development & Control, and Sensory Receptors.

A comparision between the 1974 and the 1986 Biology program in British Columbia is made in table 6.2. As shown in the table, the 1986 Biology 11 & 12 Program is more highly structured than the previous one, the 1974 Biology Program. Each core and optional topic is clearly outlined in terms of what material to cover, how much time to spend, and what learning outcomes to achieve. This, of course, gives little chance for misunderstanding or misleading approaches.

Table 6.2
The comparison between the 1974 and the 1986 Biology Program in B.C. Canada.

	1974 Bio. Program		1986 Bio. Program	
	Bio. 11	Bio. 12	Bio. 11	Bio. 12
Structure	Structured		Highly Structured	
Core Section	90%	90%	70%	80%
Optional Section	10%	10%	30%	20%
Core Learning Outcomes	No	No	130	189
Optional Intended Learning Outcomes	No	No	272	100
Textbooks	2-3	2	1	1
Laboratory Manuals	4	2	1	1
Authorized Students' Resources	7		4	
Authorized Teachers' Resources	3	2	2	5
Supplemented Books	40+	40	21	
Approach The Topics	From the outside in; from the biome to the molecules. An ecological approach.		From within and out; from the atom to the biome.	

An analysis of the Biology 11 & 12 Curriculum Guide

This analysis of the Biology 11 & 12 Curriculum Guide uses Eisner's five basic orientations to the curriculum, Bloom's taxonomy of educational objectives, a test for congrency, as well as information from chapter one, two, and three of this thesis.

Eisner's five basic orientations to curriculum Eisner's five basic orientations to curriculum are the development of cognitive processes, academic rationalism, personal relevance, social adaptation/social reconstruction, and curriculum as technology. In the development of cognitive processes, Eisner (1985) maintains that the emphasis is on process as opposed to content. Thus, it is not what facts the students learn, but how the students go about learning that is important (Eisner & Vallance, 1974). There are two assumptions at work here. First, specific processes can be isolated and cultivated and, second, that these processes can be transferred to other areas and situations so that the student is learning how to learn (Eisner & Vallance,1974). Student tasks, therefore, should be tasks which are intentionally designed to foster the use and development of specific processes. Such tasks are not tied to specific content (Eisner & Vallance,1974); content serves only as the vehicle for the student to develop and use processes and skills (Eisner, 1985).

A second orientation focus to the curriculum is academic rationalism. In this orientation, the emphasis is on passing on what is most worthwhile from the great thinkers of the past in the traditional subject areas (Dukacz & Babin, 1980), so that, while intellectual growth is stressed (Eisner, 1985), it is accomplished through a study of the very best content and most significant ideas in the various fields (Eisner, 1985). The central aim "is to develop man's (sic) rational abilities by introducing his rationality to ideas and objects that represent reason's highest achievements" (Eisner, 1979, p. 68).

The third orientation focus is personal relevance. Eisner (1985) describes this orientation as emphasizing the "primacy of personal meaning." Programs are developed by teachers and students together within a resource-rich environment provided by the school, where the individual student has the freedom to choose what to study (Eisner, 1985).

Social adaptation and social reconstruction, with a focus on social relevance, form the fourth orientation. Here, social analysis provides the basis for the curriculum, whether it is adaptive (helping the student adapt to changing conditions) or reconstructionist (helping children identify problem areas in society and work towards change in those areas) (Dukacz & Babin, 1980).

Curriculum as technology is the fifth orientation and it focuses on process, but not the process of learning. Its main thrust is efficient presentation of material (Eisner & Vallance, 1974). Goals are stated in reference to observable behaviour, and tasks in such a curriculum are sequential (Eisner, 1985). In short, curriculum as technology which is "...consonant with the Western world's efforts to control human activity", is normative, means-ends, structured, and sequential orientation. Moreover, its "...quality-control procedures are conceived of not just as a possibility but as an educational necessity" (Eisner, 1985, p.80)

Since each of these orientations is designed for different situations, it follows that, each has a direct bearing on the kinds of opportunities for learning that students are provided, and that the provision of learning opportunity is probably the single most important factor influencing course content in school. Thus, these orientations are a useful framework for the analysis of curriculum.

The following is a summary of conclusions based on Eisner's orientations to the curriculum as shown in table 6.3.

When the rational, goals, and intended learning outcomes stated in the Bio 11 & 12 curriculum guide were classified under one or more of Eisner's five basic orientations to curriculum, the rationale statement, philosophy, and goals relate only to cognitive processes, personal relevance, and dissemination of social values. Both the rationale and the program goals advocate the development of cognitive skills and the need for a solid background of knowledge in science for future academic study. What the program goals do not mention is the importance of understanding the impact science and technology have on our society, and particularly the way they have affected the work place and living environment. Thus an imbalance between the rationale and program goals exists.

Furthermore, as shown in table 6.3, it seems that the learning outcomes emphasize student accumulation of scientific knowledge and his/her development of cognitive skills. This fact becomes obvious when we apply Bloom's taxonomy of educational objectives to the intended learning outcomes of the 1986 Biology 11 & 12 program.

Table 6.3
The relationship between Eisner's five basic orientations to the curriculum and the rationale, goals, intended learning outcomes and learning topics sa stated in the 1986 Bio 11 & 12 Curriculum Guide

The Basic Orientations To The Curriculum	Rationale of Bio. 11/12	Goals of Bio. 11/12	Learning Outcomes	Learning Topics
Cognitive Process	Evidence	Goal D&(B,C)*		Evidence
Academic Rationalism	Evidence	Goal C	Evidence	Evidence
Personal Relevance	Evidence	Goal (A)*		
Social Adaptation/ Reconstruction	Evidence	Goal A		
Curriculum as Tech.			Evidence	

* Means only a statement or accompany statements of those goals. The development of scientific attitudes and critical thinking abilities goals (A & D), the scientific skills and processes (goal B), and knowledge (goal C).

The second criterion for evaluating the 1986 Biology 11 & 12 Curriculum Guide is Bloom's taxonomy of educational objectives, which are knowledge, comprehension, application, analysis, synthesis, and evaluation. This taxonomy, based on the notion of a cognitive domain (Krathwohle, 1973), provides a framework around which educators can examine congruency in either the classroom or in a curriculum guide. Each successive category is assumed to require students to demonstrate thinking behavior more complex and abstract than they demonstrated in the previous category. This means that the categories are arranged from simple to complex behavior, and from concrete to abstract behavior. For example, knowledge and comprehension, which are at the lowest level of understanding, deal with specific knowledge, terminology, methods, conventions, trends and sequences, classifications and categories, criteria, theory, translation, interpretation, extrapolation, etc. On the other hand, synthesis and evaluation, which are the highest levels of understanding, deal with organizing information, producing results with the emphasis on uniqueness and originality, analyzing and evaluating data or conclusions in terms of internal evidence, logic, consistency, etc., and evaluating in terms of external evidence and applying satisfactory criteria. Typical forms to describe learning outline Bloom's educational objectives are shown in table 6.3.

Table 6.4
Typical forms to describe learning outline Bloom's educational objectives

Educational Objectives	Typical Form of Question Cues
Knowlege Level	Define, Describe, Did you know that, Does, Identify, List, Relate, State, Tell, What do you remember, When, Where,Which, Who, etc.
Comprehension Level	Change to different symbol or medium, Compare, Contrast, Describe how you feel about, Discover and explain, Interpret, Relate, Tell in your own words, What is analogous to, What does it mean, What are the relationships, etc.
Synthesis Level	The synthesis level uses open-ended question cues such as "Create, Combine, Compose, Develop, Design, Devise, Estimate, Imagine, Infer, Invent, Hypothesize, Predict, Produce, Suggest, Suppose, Think of, What would happen if, What would it be like, Write, etc.
Evaluation Level	Are these solutions, proposals, procedures, etc. adequate, Choose, Debate, Decide which, Discuss, Editorialize, Evaluate, Judge by how you feel, Recommend, etc.

The following is a summary of conclusions based on Bloom's cognitive taxonomy.

As shown in table 6.5, in light of Bloom's cognitive taxonomy, the intended learning outcomes are mostly written at the knowledge and comprehension levels (lower level objectives). They reflect low percentages of upper level cognition. The word cues of performance objectives such as describe, explain, identify, outline, contrast, compare, etc., are common in the intended learning outcomes. If our objective, for example, is to promote higher cognitive skills, then we must provide learning materials, raise expectations conducive to achieving higher objective levels, and provide the right teaching and learning environment. Objectives such as "analysis" or "synthesis" can not be achieved by teaching and evaluating students in "knowledge" or "comprehension" levels and visa versa. [1]

Table 6.5
The word cues in the 1986 Biology 11 & 12 Learning outcomes
Based upon the use of Bloom's cognitive taxonomy. Most of the core and optional learning outcomes are written at the knowledge and comprehensive levels of performance objectives.

	Core Areas		Optional Areas	
Word or Question Cues	Bio. 11	Bio. 12	Bio. 11	Bio. 12
Compare	8	8	18	5
Contrast	10	9	18	4
Define	12	11	16	9
Describe	**45**	**43**	**90**	**26**
Differentiate	5	10	2	3
Explain	**12**	**23**	**22**	**14**
Identify	14	21	31	6
List	11	13	7	6
Outline	**10**	**10**	**20**	**12**
Relate	2	13	6	4
State	1	12	3	3
Suggest	2	2	16	2

Any word cues repeated less than ten times were eliminated from this table. A complete list of all the word cues can be seen in appendix 6.2.

Furthermore, I found no relationship in the curriculum guide of Biology 11 & 12 between objectives, experience and evaluation levels in the classroom. This indicates that there is no clear congruency between the rationale and goals of the program and the intended learning results. With such incongruency, it is not known whether teachers will be able to teach toward the development of a student's optimum level of cognition or merely for knowledge and comprehension. With dominant words such as ' Describe',

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[1]-Another useful criterion for the analysis of curriculum was found in Marvin Wideen's (July 2, 1987) public lecture "The Hidden Determiners of the Secondary Curriculum " in the Summer Institute on Teacher Education at Simon Fraser University. I agree with Wideen's claim that curriculum development occurs at three different levels. The first one is the Visionary level or how philosophers of education theorize about the curriculum. At this level, curriculum usually remains in the theoretical realm. The second one is the official level in which the Provincial Department of Education writes down the curriculum in the form of curriculum guides, supplementary materials, and textbooks. The third level is the practical level or how it actually happens in the schools and in the classroom. In other words, curriculum is developed by philosophers of education, public officials, and school teachers. All these experts have their own backgrounds and opinions in the development of a curriculum. Yet, in order to achieve the desired goals, these three groups of experts have to consider and agree on certain principles such as primacy of goals, congruency, and variety in the development of a given curriculum.

'Identify', 'Contrast', 'Outline', 'List', teachers are asked to teach recall rather than application, analysis, synthesis, or evaluation. Thus, the 1986 Biology 11 & 12 learning expectations reflect behavioral objectives that do not aim at the upper levels of cognition. Therefore, in the existing gap between the rationale and objectives, and classroom practices in learning expectations, there is doubt that the primary goals will be achieved especially if teachers opt for methods and subjects, based solely on content and learning expectations. In short, in the light of Bloom's cognitive taxonomy, the learning outcomes of the 1986 Biology 11 & 12 indicate that this program was developed for lower levels rather than for both lower and higher levels of cognition. If a given science course emphasizes lower cognitive skills, Journet (1985) argues "it is little wonder that texts do also "(p. 237). The analysis of the study questions of the two main selected biology textbooks for Biology 11 & 12 Program supports this finding.

An Analysis of the Two Main Biology 11&12 Textbooks

General Description

The two main biology textbooks selected to be used in grade 11 & 12 are *Inquiry Into Life* and *Macmillan Biology*. A comparision between the two texts is shown in table 6.5.

Table 6.5
The comparison between the two main biology textbooks (*Inquiry Into Life and Macmillan Biology*) being used in B.C. Biology 11 & 12 Program.

Items	Macmillan Biology	Inquiry Into Life
Number of Chapters	38	35
Number of Pages	799	816
Number of Study Questions	1918	386
Average Number of study Questions Per chapter	50.5	11
Number of Pages of B. C. Supplement	44	16
Number of Study Questions of B.C. Supplement	24	22
Kind of Questions*	4	1

* *Macmillan Biology* contains four kinds of study questions; regular questions, checking the facts, using science vocabulary, completing the ideas, and applying the concepts. In both " checking the facts " and " using science vocabulary " students need only to write the number of each phrase or items and then match it

An Analysis of the Two Main Biology 11&12 Textbooks

This analysis of the two main biology textbooks uses Bloom's taxonomy of educational objectives, and the information from chapter one, two, and three of this thesis. After reading all the learning questions in the two texts I analysized them based on Bloom's taxonomy. Tables 6.7 & 6.8 contain the most common question cues in *Inquiry Into Life and Macmillan Biology* and the B.C. Biology Supplement in these two texts respectively. As shown in the two tables, the analysis of the study questions shows that the question cues of the lower levels of Bloom's cognitive taxonomy dominate. The question cues of the upper levels of Bloom's cognitive taxonomy including, for example: Create, Combine, Compose, Develop, Design, Devise, Estimate, Imagine, Infer, Invent, Hypothesize, Predict, Produce, Suggest, Suppose, Think of, What would happen if, What would it be like, (synthesis level questions cues), Are these solutions, proposals, or procedures adequate, Chose, Debate, Decide which, Discuss, Editorialize, Evaluate, Judge by how you feel, Recommend, (evaluation level question cues) are relatively low in both texts. Thus, the analysis of the question cues of the two main biology textbooks in use in biology classrooms shows similar results to the analysis of the learning outcomes of the Bio 11 & 12 Curriculum Guide.

with the best descriptive term or answer. In the question of " completing the ideas" students need only to copy the number of each item and then write the word or phrase that best completes each sentence. The questions of "applying the concepts" demand more than just memorizing facts. They require searching for information, investigating, analyzing and discussing issues. However, the percentage of this kind of question is too low compared to the other kinds of questions.

Table 6.7

The question cues in the study questions of the two main biology textbooks (*Inquiry Into Life* (1985) *and Macmillan Biology* (1985)) being used in B.C. biology 11 & 12 classrooms based upon the use of Bloom's cognitive taxonomy. Most of the study questions are written at the knowledge, comprehensive, and application levels of performance objectives.

Question Cues	Macmillan Biology	Inquiry Into Life
Compare	10	16
Complete the idea	189	
Copy (match) the number	235	
Define	60	19
Describe	154	77
Discuss	5	44
Distinguish	22	2
Draw/ Draw conclusion	6	17
Explain	89	29
Give	38	54
How	151	47
List	39	9
Make prediction/ make to show	18	
Name	22	55
State	15	9
What/in what/ of what/ to what	311	144
Which/in which	11	17
Why/ Why not	47	18
Write (match) the correct #	235	

Any question cues repeated less than ten times were eliminated from this table. A complete list of all the word cues can be seen in appendix # 6.3.

Table 6.8
The question cues in the study questions of the B.C. Biology Supplement in the two main biology textbooks (*Inquiry Into Life and Macmillan Biology*) being used in B.C. Biology 11 & 12 classrooms. Based upon the use of Bloom's cognitive taxonomy, most of the study questions are written at the knowledge and comprehensive levels of performance objectives.

Question Cues	Macmillan Biology	Inquiry Into Life
Compare		1
Define		1
Describe	2	11
Differentiate		1
Discuss		3
Explain	4	2
How	4	
Identify		3
List	2	3
Outline	1	2
What/ in what	14	
Why	2	

To find out why such a gap exists between rationale and goals on one side, and the learning outcomes and learning content on the other, I talked with two members (biology teachers) of the Biology 11 & 12 Curriculum Revision Committee, which developed and produced the current Biology 11 & 12 Program. They agreed regarding the lack in congruency between the rationale statement, program goals, and intended learning outcomes. One of them stated that "this situation was caused by external forces." The other stated that the current Biology 11 & 12 Program could be good, if combined with its optional area and with Science & Technology 11. He added that the core curriculum by itself "might not be sufficient, especially in terms of ecology and its associated themes and issues." My question here is: can teachers find time to teach optional topics after they cover the core area occupying 70-80% of biology 11 & 12? Of course not, unless, as Gardner

(1979) argues, the core area contains no more than 50% of teaching time; "Then options can be developed to enrich the curriculum in other ways and to satisfy differences in individuals and systems"(p. 30). But, regardless of how Biology 11 & 12 came about, the curriculum has been reduced to the level of a nearly endless stream of conclusions in order to satisfy learning expectations. If it was decided at some point to present a view of biology different from that outlined in the rationale, philosophy and program goals, then the latter should also have been changed.

Learning expectations should derive from all goals of the given discipline. Many learning outcomes for Biology 11 & 12 are specifically derived from the goals, or directed toward the goals, of scientific skills and processes (goal B), and knowledge (goal C) assuming that these outcomes sometimes encourage the achievement of the other goals (A and D). The development of scientific attitudes and critical thinking abilities are examples of goals (A and D). It is hard to believe that the inculcation of scientific attitudes and critical thinking abilities in students can be guaranteed when the learning expectation is directed only toward developing scientific knowledge, skills and processes. Furthermore, the goals of scientific skills and processes (goal B), and knowledge (goal C), are derived from the core areas of the curriculum rather than from both its core and its optional areas. Thus, some goals stipulated in the curriculum guide of Bio 11 & 12 are either ignored or inconsistently realized by the core of Bio 11&12.

Unlike Science 1-7 or Science and Technology 11, in the new Biology 11 & 12 Program there are virtually no alternate or innovative teaching strategies teachers might adopt, at least until they become familiar with the new program. Instead, the curriculum guide states that "the teaching methods used are left to the professional judgement of teachers." This is fine, except that such a curriculum might leave the teacher little choice but to teach science in a doctrinaire fashion in order to cover the core materials, and to be accountable for the learning outcomes. The philosophy does, however, state that "as a scientific discipline, biology is also defined by its methods of inquiry, and characterized by the social context in which biological research is done and biotechnology is used"(p. 3). But the curriculum guide does not go into detail, nor does it give the teachers real insight into how the developers of the curriculum intended it to be taught. Again, this could be interpreted as an invitation to encourage teachers to use different teaching techniques and discover by themselves effective teaching models.

The curriculum guide for Biology 11 & 12 promises in its opening pages to relate biology to society; however, it fails to give sufficient emphasis to the relationship between science, technology and society, which was one of the main reasons for the revision. In the comprehensive list of intended learning expectations which follows, there is little evidence that the curriculum designers have taken their own intentions to heart. It is clearly understood that a recommendation to emphasize a science-technology-society relationship in science education, made in the Science Council of Canada's (1984) report 35, was one of the motivations for this revision. It is also understood that a relationship such as this requires the consideration of the socio-cultural, economic, and environmental impact of a given science. Yet, a relationship such as this was conspicuously absent from the goals (one part of goal "A" is an exception), and the core section of the curriculum. A survey of the dozens of specific intended learning outcomes (the concrete, testable facts and skills of the Bio 11 & 12 curriculum) finds the rationale and philosophy almost entirely forgotten.

The program goals do not mention the importance of understanding the impact that science and technology have on our society, and particularly the way they have affected the workplace and living environment. The importance of such understanding appears, however, in the optional part of the curriculum in four areas: Silviculture, Bioethics, Careers in Biology, and Aquaculture. While bioethics requires both a higher cognitive and affective domain of thought from the students in order to understand the underlying concepts, the other three optional areas are loaded with knowledge level questions. In short, even though these optional technological areas of the curriculum require a higher proportion of the upper cognitive domain of learning outcomes than most of the other areas in both core and optional sections of the curriculum, the aim of addressing science-technology-society relationships in the curriculum is not sufficiently carried out. Two of the Revision Committee members of the Bio. 11 & 12 program with whom I talked, agreed with this and hoped that Science and Technology 11 will fill the gap.[1]

Furthermore, while the rationale, philosophy, and goals of the 1986 Biology 11 & 12 give promise to cognitive processes, personal relevance, and dissemination of social values, the intended core learning expectations do not sufficiently emphasize these promises. For example, they do not develop the student as a social being, nor encourage him /her to be a decision maker. The guide does offer optional units providing some controversial aspects, questions of ethics and values and the global perspective, as well as ecological subjects, but in view of the depth of core areas, there is little room for exploring optional topics. Optional topics such as these are in danger of being eliminated in rushing (by both students and teachers) to complete the core area. In addition there may be a tendency among some teachers to believe that optional topics are less important than the core ones. Thus, because of the inadequacy of the core, and, to a lesser degree, of the optional topics, there appear to be no congruency between the rationale and program goals and the intended learning outcomes.[2]

1- Educationally speaking, Science and Technology 11 is a good course in terms of its rationale, philosophy, stated goals, and the scope of the course. Yet, its problem is that it has already been perceived by some students as a science course for less able students, thus a negative attitude toward taking it has already grown among brighter high school science students. One of the teachers I interviewed in this study asserted that: "...it turned out that (at our school anyway), the students that take Science and Technology 11 are either students who have taken modified science courses, either because of lack of ability or lack of desire to work hard, and so now they're out there taking Science and Technology 11 because it's reported as being less rigorous then the other science 11 course. I'd say 3/4 of the students in my S&T courses are in that category. And then, you get a few arts students that are not interested in science and are academically inclined and might go on to university. But the majority of the students are the non-academic students."

2- It is clear that the trend in the current biology 11 & 12 program has shifted from scope and sequence to core and options, and the rationale behind this shift may be to meet not only the demands in professional literature for such change, but also to provide at least a minimum of biological learning for every secondary school biology student in B.C., Canada. This is, of course, fine, especially if this core as Gardner (1979) argues "...can be held to no more than 50 % of teaching time. Then options can be developed to enrich the curriculum in other ways and to satisfy differences in individuals and systems."(p. 30) But, as I already stated in the general description of the curriculum guide, the core area of biology learning occupies 70 - 80 percent of the biology 11 &12 curriculum, leaving insufficient time for enriching the curriculum or satisfying differences among individual students.

Ecology has been de-emphasized in the existing Biology 11 & 12 program. In many cases, the tasks of ecology are either ignored or inconsistently realized. Yet, looking at core and optional areas, Biology 11 is more ecologically based than Biology 12. The old Biology 11 program was about 30% ecologically based, though the new biology 11 program is less so. While teachers had to teach ecological topics in the 1974 Biology 11 & 12 program, teaching ecology in the 1986 biology 11 & 12 program depends entirely on the background of the teachers and their will to choose ecological topics or related themes that can be emphasized ecologically.

In short, there are aspects of all of Eisner's orientations in the B.C. Biology curriculum guide, but the emphasis is not the same for all five; the strongest affiliation is in the development of cognitive processes orientation, and the minor orientational influences are academic rationalism, social adaptation and social reconstruction, and curriculum as technology. In addition, the development of the cognitive processes in the curriculum are emphasized more on the level of knowledge and comprehension than on other levels of Bloom's taxonomy such as application, analysis, synthesis, and evaluation. The analysis of the study questions of the two main selected Bio 11 & 12 textbooks supported this fact. The new Biology 11 & 12 program *could be* an ideal course in terms of value and ethical questions, the global perspective, the interdisciplinary nature of social and environmental problems, as well as other biological and ecological themes, *if* the optional area of Bio 11 & 12 and Science and Technology *were integrated with* the core curriculum of Bio 11&12 and then, re-structured and re-organized. Without such modification, the new Biology 11 & 12 program seems insufficient to meet even the stated rationale, philosophy and goals of the biology curriculum. From an ecology education point of view, such modification is critical since as McClaren (1987) indicates, there is "...no course, or even course unit or topic within the entire provincial curriculum that is actually titled "Environmental Education' " (p. 51).

Biology and Ecology Teaching Observation

As indicated in chapter four, six teachers were observed teaching biology and/or ecology topics. In order to identify the common teaching models used in those biology and ecology classes, I used Joyce and Weil's (1980) four families of models of teaching which are: (1) Informative-Processing Family Models; (2) Personal Family Models; (3) Social-Interaction Family Models; and (4) Behavioral Family Models. These four families represent "distinct orientations toward people and how they learn" (p. 9). As mentioned in chapters four and five, all teachers who participated in this study were provided with a list of these models and the goals outlined in applying them. The aim for providing teachers with this list was to make sure that they were aware of a variety of other teaching models.

Examples of teaching observation

In general, the observed teachers introduced the new topic orally and by writing on the chalkboard or overhead projector[1] with reference to previous classes and previous student experiences. Then, new concepts were introduced and explained by the teacher.

Example one: The teacher asked students to read for 10-15 minutes, particular pages in the Bio 11 text. Then the teacher selected certain questions from the previous homework and explained them. He spent considerable time explaining questions related to energy. For example, he drew an energy pyramid with a carrot on the bottom and a wolf on the top. Then he explained why there was less energy at the top of an energy pyramid than at the bottom. To make sure that students understood this concept, the teacher said, "Now, you are shipwrecked on a cold, arctic island. You have with you 50 chickens and 500 boxes of cereal. How can you get the most energy and the longest length of survival from what you have? There is no way to be rescued." Students wrote their answers, the teacher collected them. After he read some of them, he was disappointed that they could

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1- Such as The web of life, The foundation of life: energy and matter, Animal kingdom, Organization of the animals, Cellular specialization - differentiation, Anthropoda, The rain forest.

not understand the concept of energy. He answered the question and proceeded to adopt the lecture format.

Example two: The teacher asked students to watch video tapes about the rain forest and to answer some questions related to the subject. Students were watching and writing notes and/or answering the questions. After the tape ended, the students left the classroom.

Example three: In one of the Bio 12 classes the teacher started by asking students questions about the last class, "Fertilization and Division", to refresh their memories. He spent half the class asking questions, explaining answers, and making references to the Provincial exam. Then, he introduced the reproductive system through diagrams of the male and female reproductive systems in pigs on the overhead projector with the object of naming every part of the system. He emphasized the importance of knowing the parts of the system and how they work. Then pairs of students dissected the reproductive system of a real pig. At the end the teacher gave students three questions as homework.

Example four: The teacher wrote on the blackboard what he was going to do that day: 1) Finishing Earthworm, 2) Starting the phylum Arthropoda, and 3) Starting the class arachnida. The teacher asked many questions and then he said the subject for today was adaptation in the earthworm. From here, he lectured by using diagrams and pictures until the end of the class when he handed out an activity sheet for students to fill out. He also asked students to look at the samples of arachnida which he placed on the table for them.

Example five: The teacher asked students to read from the text and then he asked "What is protoplasm? Is the sponge a large mass of protoplasm?" From here, he talked about protoplasmic and cellular organization. The teacher then asked students to read further to find out the definition of tissue. From there he talked about the cellular structure, function, and the characteristics of hydra and obelia. Later students observed prepared slides of an obelia colony, drew it, and wrote the names of all the parts, and listed their characteristics. Students also observed live obelia under the microscope.

In all observed biology classes, students often had the opportunity to speak with the teacher on the subject. This interaction increased toward the end of the class. Students also took notes, answered questions and worked on activity sheets, which were common in most classes, especially in Biology 11. Almost ninety percent of the materials and questions in every activity sheet I saw covered factual knowledge and science terminology introduced in previous classes. In most classes, the personal and social relevance of a given subject was disregarded. Lectures, discussions, and textbook assignments, and infrequently, the use of environmental simulation games, were the most common teaching technique. Four teachers, however, expressed awareness that these types of teaching might not be the most effective. They made it clear that they have been trying to adopt and implement active participation but that there were external inhibiting factors.

Analysis of the teaching observation

Using Joyce and Weil's (1980) four families of models of teaching as an observation framework, almost all of the classroom teaching strategies observed reflected aspects of the " Behavioral Family of Models", which include models for " teaching facts, concepts, and skills as well as models for reduction of anxiety and for relaxation" (Joyce and Weil, 1980 p. 12). Few teaching strategies extended into the"Information-Processing Family of Models", which depend on "activities that carry content and skills" (Joyce and Weil, 1980, p. 12).

The common thrust among the behavioral teaching models is "an emphasis on changing the visible behavior of the learner rather than the underlying psychological structure and the unobservable behavior" (Joyce and Weil, 1980, p. 12). While control over the learning situation in behavioral teaching models can be in the hands of either teachers or students, in the observed classes the teachers controlled the learning situation.

Six teachers indicated that they would like to experience teaching models such as inquiry training, scientific inquiry and cognitive synectics, and classroom meetings

(Personal Family Models); and social inquiry, group investigation, and laboratory method (Social Interaction Family Models). It was clear that they were aware of the advantages of models such as these. They seemed to be familiar with Joyce & Weil's statement that social interaction models "give priority to the improvement of the individual's ability to relate to others, to engage in democratic processes, and to work productively in society" (Joyce and Weil, 1980, p.11). Furthermore, models such as these are also important in "the development of the mind and self, and the learning of academic subjects" (Joyce and Weil, 1980, p. 11). The majority of observed teachers indicated that they would like to experience the social interaction teaching model, but felt they not only lacked the right training in order to effectively implement it, but also the right environment (e.g., low teaching load, low pressure from the governmental exam, more flexibility of the school system, etc.)

In terms of instructional resource materials, no single use of resource personnel in biology and ecology teaching was observed. Observed teachers, however, told me that they usually do use guest speakers from government and private organizations as well as from local business and industry.

During the period of observation, only one teacher took his Biology 11 class on a field trip to a fish hatchery sponsored by the science teachers and students of that school with some funding from the Imperial Oil Company. Even though the primary purpose of the trip was to collect data and information about salmon, the hatchery, and the impact of this hatchery on the community, no written information was given to the students nor did students try to take notes. The teacher did, however, give an illustrated talk about the history of the hatchery, its goals and objectives, fish species, and the impact of this hatchery on the local community. He also complimented those teachers and students who had been involved in maintaining the fish hatchery in order to encourage other students to participate in the fish hatchery program. Again, all observed teachers indicated that they take their students for field trips at least once or twice a year, and also to the schoolyard or a park within walking distance at least three or four times a year, especially in the spring semester.[1] In fact, one teacher gave me an itinerary for an ecology field trip he had planned for the end of the school year.

After talking to the teachers, I felt that field biology and ecology are restricted to the spring and/or summer semester. Winter ecology doesn't exist and/or is not popular in secondary school biology teaching, at least in observed classes and amongst interviewed teachers. In areas such as B.C. (Canada) especially in the north, where rain and/or snow are present at least four or five months of the school year, field ecology in the spring won't cover the full spectrum of the ecosystem. It has been widely stated that " winter is the perfect opportunity to introduce students to the concepts of ecology--the perfect time to see the interaction of organisms with their environment more clearly. In winter, harsh environmental conditions pose challenges for survival; for how an organism adapts to and interacts with its environment is crucial [for understanding ecology]" (Birkeland and Halfpenny, 198 p.43).

In summary, the teaching techniques observed combined lectures, discussions, and textbook assignments, and infrequently, the use of environmental simulation games[2] in most teacher controlled learning situations. Some teachers noted that these approaches might not be the most effective ones. They made it clear, however, that they have been trying to implement active participation methods (e.g., inquiry, group discussions, debates, court system methods), but that there were external factors inhibiting them from effectively doing so. The general methods of value clarification such as use of controversial incidents, voting, role playing, value clarifying discussions, rank ordering, pictures without captions, etc., which literature claims important in developing environmental awareness, were rarely

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1 - This result is similar to Keown's (1986) findings on the use of outdoor resources among U.S. secondary schools. Keown's (1986) survey indicates that the majority of American secondary school biology teachers take their classes out-of-doors for activities during one class period no more than twice. The survey also indicates that about 16% of biology and earth science classes don't go outdoors at all.

2 - Approaches such as these were noticed by Bottinell (1976) in secondary environmental education in Colorado.

used during the observation. Once, however, I observed a teacher using pictures without captions from the first chapter of the Green Version of BSCS to involve students in group discussion and value clarifying discussions. In short, if the major purposes of teaching biology at the secondary school level as presented by the curriculum guide of Bio 11 & 12 are to show the student that he/she is simply another living organism, to provide an understanding of how the human body functions, and address the nature of scientific inquiry, then teachers need to understand and use a diverse teaching approach.

The following section deals with the question of what the nature of ecology is in Lower Mainland British Columbia today and how it is being taught.

Summary and Discussion of The Nature of Ecology Education Today and How It is Being Taught

This section summarizes this chapter and chapter five and discusses the nature of ecology education in lower mainland, British Columbia today.

Ecology in secondary school science education in B.C., Canada, is currently taught within the biology education program. Furthermore, the biology curriculum in B.C. has just experienced a revision, as have all the science education courses, in an effort to improve science education in the province. The current Biology 11 & 12 program, which was implemented in1986, contains less ecology and associated subjects than did the previous biology program. See appendix 6.1, 6.2, 6.3 and 6.4.

In the 1986 revision of biology education, ecology and related subjects are found almost exclusively in the optional sections of the curriculum and are virtually non-existent in Biology 12. Most of the ecological themes being taught are the most basic biological concepts such as the food web, energy flows, material cycles, succession, habitat and niche, biomes, etc., which do not go beyond the physical aspects of the environment. They are generally represented as mere facts. They fail to develop an insight into: how ecological systems work, a sense of the fragility of the living world, or to show the limits of planetary resources. These concepts tend not to include social and environmental issues and processes, nor do they develop intelligent action skills and processes related to ecologically responsible behavior. Learning facts in biology is necessary, but only as a means of gaining an increased understanding of concepts and principles as well as in developing intellectual abilities and skills necessary for problem solving, critical and reflective thinking (Points, Brown, and Greig, 1971) and moral growth. Ecology today has been extended beyond the phycial environment to include social, economic, aesthetic, political, and other questions.

Secondary school biology teachers who participated in this study on the whole recognize the importance of ecology, and most expressed regret that the current biology curriculum is devoid of ecology. Yet only a few biology teachers have committed themselves to teach ecology. Regardless of the teachers' belief that ecology is too important to be left out of school biology, only half of the participants in this study, for example, integrate some eco-physical concepts and principles into their biology curriculum. Those teachers who still manage to teach some ecology are unsure as to whether they will be able to continue doing so in the present Biology 11 & 12 program.

The teaching style I observed in biology classes in the Lower Mainland appears to be the traditional lecture, accompanied by worksheets, highly structured labs, and in most cases some formal/informal field work; in other words, direct teaching with content emphasis in a totally controlled learning situation. Rarely did I see any attempt at an inquiry approach or the use of research projects. Participating teachers claimed that the nature of the educational system and the incredible pressure of passing the governmental exam (as well as scholarship exams to some extent), have encouraged them to adopt traditional techniques of teaching, even when they prefer more progressive and productive methods. Indeed, while most secondary school biology teachers still use lecture and teacher led discussion, many of them are already aware that the highly effective methods of teaching environmental topics are those which involve students as active participants rather than as passive spectators. Furthermore, the analysis of the teaching observation indicated that there is a serious gap between the stated intentions of many of the teaching examples reviewed and their actual practice. Frequently, the students are left hanging in the air as if the actual purpose of an exercise had been forgotten.

The core curriculum consumes over 70% - 80% of the biology 11&12 program and, according to many teachers, consumes 90 to 95 % of teaching time. The new curriculum doesn't allow room to concentrate on class discussions, projects, invitations for inquiry, case studies, group investigations, etc. Even though more innovative teaching techniques are preferable, the inflexibility of the educational system and pressure from the governmental exams hinder anything other than the traditional style of teaching of content through the lecture approach in a totally controlled learning situation.[1] Time is not only needed to conduct effective field work and employ effective teaching strategies, but is also necessary for teachers themselves, in order that they might be able to explore libraries, museums, and parks, and observe their peers in order to expand their understanding of the subject and perhaps find new methods for teaching it. If, for example, we want to develop and encourage critical thinking, then considerable time has to be set aside to deal with such processes rather than with the accumulation of mere biological and ecological facts.

Biology education at the secondary school level (as shown in chapters three and six), has four main goals: the provision of biological knowledge, the development of scientific skills and processes, the development of scientific attitudes and the development of critical thinking abilities. Yet, the last two (the develpment of scientific attitudes and critical thinking ability) are either ignored or realized inconsistently by the core of the Bio 11 & 12 curriculum. The only reason given in the Bio 11 & 12 curriculum guide for this neglect is that, the achievement of the first two goals (having biological knowledge and

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1 - In effective ecology teaching, teachers need to be adaptive in order to carry out competent environmental work, but their adaptability usually stems from the flexibility of the educational system itself within which teachers function.

scientific skills) might somehow result in the assimilation of the other two. It is hard to see how the four goals can be achieved when the learning outcomes of the second two are only found in the optional areas, which represents 30% of the curriculum. In summary, the Biology 11 & 12 program lacks an appropriate balance of all given goals. This fact is clear also in the findings of the analysis of both the learning outcomes of the Bio 11 & 12 curriculum guide and the study questions of the two main selected biology 11 & 12 textbooks. The findings of this analysis indicate that most of the objective learning outcomes and the question cues of the study questions reflect the knowledge and comprehension levels of Bloom's cognitive taxonomy. Furthermore, in terms of Eisner's curriculum goals, the Bio 11 & 12 curriculum guide shows that the strongest emphasis is on the development of cognitive processes, but the learning outcomes, and the observed teaching methods indicate otherwise.

A gap exists between the current content and the goals of ecology. To be more specific, the new program, teaching style, and content emphasize descriptive biological content and some scientific skills (methods and processes). Biology teachers also hope to foster the development of ecologically responsible behavior. Yet, students are not provided with biological and ecological learning experiences suited for such objectives nor with the philosophy, rationale and all goals of the Biology 11 & 12 program.

As I stated in chapter three, while some biology teachers (e.g., Illinois biology teachers in Barber's study in 1982) felt that their textbooks did apply adequate ecological concepts to environmental problems studied in the classroom, British Columbia biology teachers were more inclened to agree with the researchers in the field who.suggested otherwise.

B.C. Biology teachers also blame teacher education for ineffectiveness of ecology education and the lack of ecological interest in secondary school curriculum. If there is in-service ecology education in most school districts in B.C. at the secondary school level, the participants seem unaware of it. Also, if the colleges and universities in the area provide inservice ecology education on a regular basis for secondary science teachers and science student teachers, the surveyed teachers were also unaware of it. If courses and workshops in designing and learning ecology and environmental sciences are available on a regular basis and teachers are unaware of them, then this reflects the generally low participation by secondary school biology teachers in formal courses such as these. If there is no teacher education (pre- and inservice education) in ecology and environmental sciences, and the majority of the teachers have never been trained to teach such subjects, then we should not blame teachers for ineffectiveness of ecology education.

What is clear, however, is that environmental education courses are not required in most pre-service education programs nor are they specific for primary or secondary student science teachers. Furthermore, it seems that many college biology programs no longer teach skills necessary for carrying out field work (such as observation, capturing, recapturing, collecting, recording, sampling, identification and characterizing the species and analyzing data) for all students. Ecology, as taught in many universities, as it impinges on teacher education in biology, is seriously at fault. Except in rare cases, biology education is also devoid of social awareness, values, ecological impact of human activities, etc. It is through pre- and inservice education that biology teachers can upgrade their knowledge and enrich their professional growth. Without participating in in-service ecology education and without suggested teaching strategies (in the Bio 11 & 12 curriculum guide) that teachers can adopt (at least until they become familiar with the new biological and ecological teaching materials) it may not be easy for teachers to develop the necessary teaching skills to achieve the goals of the new biology program.[1]

In short, there is a serious gap between teachers' goals and curriculum guidelines. There is also a gap between what the literature suggests teaching ecology should be, and

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[1]- It is the teaching approaches and processes that will influence the students' understanding of a certain body of knowledge and promote change in their thinking, attitudes, and actions.

how ecology has been taught. This gap indicates some changes are needed in ecology education. In the 1974 biology program, the subject was available in the core area of the curriculum, although the other three factors (time, flexibility of educational system, and teacher training) were still there. In the 1986 Biology 11 & 12 program, the four main factors appear to exist. Developing an ecologically knowledgeable person with adequate understanding, problem-solving ability, and the critical and reflective power necessary for behaving responsibly, seems hard to achieve through the existing biology curriculum. Appropriate attitudes on the part of policy makers and policy implementation, relevant teacher training programs, a flexible educational system and school policy, and the presence of ecology as a subject in the core of the science curriculum are all needed for effective ecology teaching.

New pedagogical views, structures, techniques and strategies must be developed and infuse at all levels (philosophy, goals, content, instruction, etc.,) of the curriculum of ecology education in order to bring about an effect education for and about the environment at the secondary school level.

Three distinct approaches to teaching ecology are suggested: 1) a full curriculum including coursework in ecology and environmental sciences; 2) an integration of ecology and ecologically associated themes into the core curriculum of the natural science courses ; or 3) a free standing ecology course, consisting, for example, of coursework over 3-5 trimesters of schooling. I have already argued in chapter one that to be fully effective, ecology must have its distinct place in the school curriculum as well as being integrated into the core curricula of related disciplines. Moreover, since, there are few secondary school science courses that deal with, or integrate ecology and its associated themes, and since developmental efforts are greatly needed, I recommend the use of the third approach; a 3-5 trimester ecology course at the secondary school level.

CHAPTER SEVEN

A Prospective Framework For Ecology Education

The purpose of this chapter is to establish a prospective framework for ecology education. The need for this framework was discussed in previous chapters (especially one, two, three, and six). Contained with the results of the panel discussions, the conclusions of these chapters serve as background for the framework of ecology education (see figure 4.2 & 4.3). I shall provide here (1) a brief description of what I mean by education; (2) a brief account of ecology education; (3) description of a curriculum prospective for ecology education; (4) description of mandatory core content for ecology education; and (5) how this core of ecology content could be taught at the secondary school level.

Education

Because ecology education exists within the field of education, the nature of education itself must be considered prior to any attempt to propose educational reform. A widely held view sees education as a human enterprise aimed at developing the mind so that students not only become capable of grasping and understanding the reality of life, themselves, society, and the natural world, but also of using wisely the knowledge and understanding they have accrued. One aim is to establish a better way of dealing with the general problems of human survival. It thus implies a process directed at producing citizens with a breadth and depth of knowledge and understanding, able to meet the challenges of their environment, and contribute positively toward building a better world[1].

This aim is consistent with the view that knowledge and understanding in their most inclusive senses are the key components of a person's education. A person's understanding of, and commitment to, say, the environment, is greatly dependent on the level of knowledge that a person possesses. It is widely believed that knowledge and

[1]- We have to keep in mind that: a) we cannot accurately predict what kind of world today's pupils will live in as adults, and b) we cannot be sure that present necessary scientific educational skills and knowledge will be adequate for the future needs of today's pupils.

understanding lead to various actions which may have desirable consequences. The ancient philosopher Avicenna (Ibn Sina) argued that wisdom is perfect knowledge and perfect action. In other words, the unity of accurate, worthwhile knowledge and desirable and positive behavior "...helps man (sic) to choose which path to take in life, and not that which is abstract and far removed from vital human needs" (Kirilenko and Korshunova, 1984, p. 38). Schumacher (1973) is right in arguing that education can only be sucessful if it produces more wisdom.

However, it is difficult to decide the kinds of knowledge and understanding that are most worth having, and when they should be taught because these are complex questions with "no universal answer for all places and all times" (Ahmed, 1980, p. 15). These questions, therefore, must be continually debated by educators, philosophers, and learners, and must receive full consideration from educators and researchers world-wide (Ahmed, 1980). When education is defined as "...a process by which people come to understand the real world they live in, how it got the way it is, how they can live productive and happy lives in it, what alternative future possibilities exist and what they can do to influence their future and fulfill their destiny" (Zlotnik,1986, p. 34-35) not only more wisdom might be developed, but also the search for what kinds of knowledge and understanding are most worth having, and when they should be taught, becomes less complex and less difficult to deal with.

This might mean that one general aim of education should be to develop an educated mind enabling humans to understand and cope with problems of survival. If education is expected to provide pupils with the facilities to pursue the truth, to reason why, and to justify action (Peters, 1973), then such facilites should broaden the base of responsibility and personal commitment to the understanding and protection of the environment, ecological processes and essential life support systems (Bird, 1977). In a world increasingly influenced by the material consequences of scientific technology, this endeavor has become increasingly difficult.

Education must look at nature as a source of knowledge about how life and life-support systems work and use this knowledge to educate citizens about themselves, their world, their future options, and how they can influence the future to fulfill their basic human needs. In other words, education should look at nature as a path to improve students' abilities to think critically and to educate themselves. However, education should focus on nature not only for nature's contribution to things we value, but also for its own intrinsic value. Otherwise, environmental neglect and destruction will continue to threaten not only our quality of life, but also our very existence.

Therefore, what and how must we teach students so they may improve and understand the quality of life, themselves, society, and the natural world? To educate, we need to ensure that students come to understand: (1) what the world we live in is like and what we are doing to it (2) what our history is; where we came from, how we got here, (3) who we are as human beings; why we look the way we do, how we can fulfill ourselves in the world, and how we are related to all other creatures, (4) what future options we have as a planetary people, and how we can influence our own future (Zlotnik, 1986). It is this kind of education I believe that can ensure the four conditions of awareness put forward by Barrow (1981) as necessary if any individual is to become an educated citizen. According to Barrow these are: First, historical awareness, broad awareness of our place and the place of our civilizations in the totality. Second, awareness of individuality, the unique quality and the power of every individual. Third, awareness of logical distinctions, the ability to understand and to distinguish logically distinct kinds of questions such as empirical, aesthetic, moral and so on. Fourth, awareness of one's capacity for discriminations; the great capacity to discriminate precisely and in detail as much as possible (Barrow, 1981, p.13). And finally, to add one more, awareness of when and "how to act or behave in difficult situation"(Cousteau, 1989, p. 6) like our present ecological crisis. Obviously, for education such as this to exist, several factors are essential. These factors will be discussed throughout the following ecology education framework.

What Is Ecological Education?

In a broad sense, ecological education is an integrative discipline that links in a holistic way the natural and social sciences with nature and humankind. Unfortunately, this basic concept is almost completely absent in present science education. The aim of ecological education is to develop a sound, ecologically educated citizen who is aware of and able to understand the complexities of natural systems and the impact of human behavior on those systems. In addition, the ecologically educated citizen should be able and willing to apply these cognitive skills, with intellectual independence, to problem-solving and decision-making processes. Specifically, ecological education should develop the ability to adapt action strategies for maintaining human life quality within a healthy global ecosystem.[1] Skills such as these are clearly essential for the young citizens who will later become the decision-makers of society.

Another way of defining ecology education is as a purposeful human activity cultivating mental processes for dealing with ecocrises and maintaining the global ecological equilibrium necessary for planetary survival, welfare, and development. Perelman (1976) argues that ecology education "...must be an effective mechanism for producing individual and social changes on a global basis to steer human society away from its current collision course with ecological catastrophe and toward a rendezvous with the stationary state" (p. 201)

In general, ecology education requires (1) a truly ecological pedagogy, not only in its content, but also in its purposes, structure, and instructional methods; (2) the examination of fundamental systems rather than separate components; (3) the use of an

1- This definition reflects those of numerous authors who have defined environmental and ecological education worldwide.

holistic view which intimately connects economics, human values, and the environment; and (4) a teaching approach that includes the development an appreciation and respect for the whole eco-sphere, and ecologically responsible behavior in everyday life. These requirements are essential because understanding implies more than environmental awareness or merely possessing unconnected bits of information. Rather, it means an empathy based on knowledge, in breadth and depth, of the holistic nature of ecology and the environment.

In short, ecology educational programs and teaching should, in the first place, include appropriate goals, aims, and objectives to meet the general educational concerns of the developing educated mind. But, in the second place, ecology education programs and teaching should contribute toward providing students with facilities required for life in a world increasingly influenced by scientific technology. They should strengthen a sense for the responsible use of science and technology.

The Goal of Ecological Education

The educational goals of teaching ecology are to develop a scientifically and ecologically literate citizenry who have global, ecological, and ecocentric attitudes toward the natural world. The most general goal of ecological education is thus to develop societies that are able to establish, develop and maintain a state of global ecological equilibrium. To this end, ecological education must encompass all types of learning, and generate the know-how and manpower capable of arriving at this "equilibrium society" (Perelman, 1976; Bybee, 1979a,1979b, 1979c; Zverev, 1982). This general goal can be resolved into more specific instructional statements, such as: (1) to develop a fundamental understanding of the basic concepts and principles of ecology and ecological systems, (2) to develop a fundamental understanding of, and ability to use the processes of scientific inquiry, (3) to develop a fundamental understanding and fulfilment of personal, human, and social needs, (4) to develop a fundamental understanding of, and ability to use critical and abstract thinking, and (5) to develop an awareness about careers in the field of ecology. These in turn, generate a set of specific aims for ecological education.

The Aims of Ecological Education

The immediate educational aims of ecological education are: (1) to achieve an accurate understanding of ecological systems, (2) to develop desirable and positive attitudes and behavior toward the environment and world ecology; (3) to educate students about the ecological ramifications of their decisions, (4) to develop desirable ecological value systems, motivation, and the ability to take personal action in order to protect the planetary environment[1] and (5) to develop the ability to think rationally and critically about the ecological implication of their own value and moral issues. Educationally oriented aims such as these should lead citizens to fulfill their basic needs, facilitate personal development, and maintain and improve the surrounding environment while conserving all available resources ecocentrically.

The Objectives of Ecological Education

The objectives of ecology education, although difficult to specify, should include:

(1) achieving ecological knowledge.

(2) having an accurate understanding of the behavior of ecological systems (both human made and natural) and their impact on human life.

(3) having an accurate understanding of the consequences of human activities on ecological systems.

(4) being able to understand and distinguish between different kinds of ecosystems.

(5) achieving an awareness of managing ecosystems for the sake of:

a) maintaining global biological diversity.

b) producing greater world food supplies.

1- Or as Leff (1978) summarized from the literature: It" ... should aim to increase not only environmental knowledge and awareness but also ecological systems thinking, ecological conscience, and other aspects of pro-life value systems, and the motivation and ability to take action in accord with all this " (p. 309).

c) controlling world population growth rate.

d) controlling world consumption of renewable and non-renewable resources.

(6) increasing interest in both ecology and environmentalism.

(7) enjoying the experiencing of ecology and the environment as part of daily living.

(8) being able to evaluate the quality of environmental information encountered in daily life and taking a position.

(9) being able to feel and enjoy the beauty of the natural world.

Core Content For Ecological Education

To meet the goal of ecological education mentioned earlier, I am proposing a mandatory ecological core content[1] consisting of the following: History of ecology, Basic fundamentals of ecology, Human ecology, Evolution, Ethics of ecology, Environmental behavior, Urban ecology, and other related topics. Table 7.1 shows how these topics are broken down into several basic subjects and sub-subjects.

Before providing more detailed examination of the proposal, it is necessary to keep in mind that what is proposed is designed to take up only a part of the typical school day; between half an hour and one hour of each school day should be devoted to ecology education. Like mathematics or language, ecology education would merely form part of the core curriculum.

It is important that this core should have a high degree of primacy of goals, congruency, and variety. I mean by primacy of goals as, how a lesson or a unit of ecology curriculum relates to the broader goals of what we are trying to achieve in an ecology classroom. Thus, the teacher must reflect on what it is s/he is teaching and why. I mean by congruency that there should be consistency and coordination among the objectives, intended learning outcomes, scope of curriculum, teaching approaches and classroom evaluation. By

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1 - To avoid confusion, I have to state that I am one of those who believe in the value of a core curriculum which may be defined as "...a content that virtually all children are required to study" (Barrow, 1985,p. 5) in order to educate them rather than to train them to "...fit in with the predicted manpower demands of society" (Barrow, 1985,p. 6)

variety,I refer to the claim that the ecology curriculum must have a range of teaching models and methods to match the varying learning styles. Since different children learn in different ways, it is very important for teachers to develop and present learning materials through different teaching approaches. It has been very well established that a single approach to teaching cannot possibly cover the wide range of objectives set out for a given program, nor can it meet all students' learning needs (Joyce & Wiel, 1980). Furthermore, the topics of this core should all be structured according to ecological educational criteria, or as Eulefeld (1976) puts it: "The topics should take into account educational criteria such as pupil motivation, the possibility of their participating in decision-making processes, and their investigation into the environment outside the school" (Eulefeld, 1976, p. 200).

Table 7.1
Core Content For Ecology Education

Themes	Topics	Subjects
Ecological History	1. History of the earth: its origin and development. 2. History of fauna and flora: origins, evolution, & distribution. 3. History of our species: its origin, distribution, and decline. 4. History of human civilizations: origins, distribution, and decline. 5. History of the recent changes in landscape environment. -------	a) Desertification. b) Deforestation. c) Erosion & mineral depletion d) Pollution. e) De-diversification or extinction. f) Ecological crises & resource conflict.
Basic Fundamentals of Ecology	1. The laws of ecology:	a) Species diversity . b) Interdependence. c) Limitation of natural resources. d) Carrying capacity. e) Exponential increase.
	2. The structure of the ecosystem:	a) Trophic level. b) Food chains, webs, & methods of nutrition. c) Ecological pyramids.
	3. The mechanisms of ecology:	a) Ecological succession. b) Dynamic motion of biophysical environment c) Energy & biogeochemical cycles.
	4. Mathematical ecology	

The Continuation of The Core Content For Ecology Education

Themes	Topics	Subjects
Human Ecology	1. Human nature. 2. Human values and human institutions. 3. Sustainability and sustainable society. 4. Man's place in the natural world. 5. Man as an ecological and cultural factor.	a) Man's role in ecological processes. b) Man's management of the environment.
Evolution	1. Principle of variation. 2. Natural Selection. 3. Evolutionary differentiation. 4. Speciation.	Elementary genetics. Genetic displacement. a) Eco-physiological. b) Morphological. c) Breeding barriers. Protected gene pools.
Ethics of Ecology . (Eco-ethics)	1. Relation among human beings. .2. Human treatment of non-human living organisms. 3. Relation between humans and nature. 4. Relationships between organisms	Survival imperative and value maintenance processes. Mutualism, parasitism, competition, etc.
Evolution	1. Principle of variation. 2. Natural Selection. 3. Evolutionary differentiation. 4. Speciation.	Elementary genetics. Genetic displacement. a) Eco-physiological. b) Morphological. c) Breeding barriers. Protected gene pools.
Ethics of Ecology . (Eco-ethics)	1. Relation among human beings. 2. Human treatment of non-human living organisms. 3. Relation between humans and nature. 4. Relationships between organisms	Survival imperative and value maintenance processes. Mutualism, parasitism, competition, etc.
Environmental Behavior	1. Cognitive knowledge of environmental problems. 2. Cognitive skills: 3. Personal factors: 4. Knowledge of what/how others did/do to solve environmental problems (in space and time).	a) Action skills. b) Knowledge of action strategies. a) Attitudes. b) Locus of action. c) Personal responsibility
Urban Ecology	1. Recognition of natural processes in the"urban"context. 2. Optimizing urban landscape to maintain sensitivity. 3. Maximizing individual participation in the maintenance of the well being of the environment and in turn, human well being.	
Other Related Topics	1. Natural Resources. 2. Future sources of energy. 3. Bio-technology and environment. 4. Maintaining contact and reverse for a healthy"natural" environment	

History of Ecology*

Science educators have already recognized the value of historical material in fostering both an accurate understanding of science and in achieving desirable, positive, and realistic attitudes towards science (e.g., Klopfer, 1985; 1969; Russel, 1981; Wandersee, 1981; 1985; Kauffman, 1987). Many ecologists and environmentalists have also recognized the importance of achieving an accurate understanding of ecology, and of developing positive attitudes and behaviours towards the environment (e.g., Diamond, 1988; Cherif, 1988; Rogers, 1985; Dubos, 1980; Keller, 1979). Moreover, because the roots of our present ecological problems are found in the ancient world (Hughes, 1975; Bilsky, 1980), "ecohistory" can help develop an accurate understanding of the causes and consequences of past and present environmental crises, and encourage effective behaviour in dealing with them. While the historical precedents of environmental crises do not form a pretty picture, Keller (1979) and Diamond (1988) believe they are full of lessons to be learned.

Since the general public forms the target population that we need to educate, desired attitudes and behaviors are not likely to be achieved unless ecohistory is learned and appreciated by all young citizens. Or, as Russell (1981) puts it, "The consequences of distorted historical content are particularly significant for that majority of students who do not become scientists" (p. 51). In general, historical awareness of the changes in the environment can be an essential element in developing ecologically aware citizens. There is a need for educators to involve, investigate, and explore the application of historical ecology to modern science education in general and biology and ecology education in particular.

By the "ecological history" or "ecohistory," I do not mean the evolution of ecology, as it is only recently that a few concerned biologists have laid down the foundations for its study. I am not suggesting using such history as the structuring principle for school

* Some of this section was published by Cherif (1988) in *The American Biology Teacher*

ecology as this approach could unintentionally result in changes in the content of school ecology classes without emphasizing real ecological processes and an understanding of ecology. Nor am I emphasizing the development of good ecological historians. What I do suggest is giving students some kind of ecological historical information in such a way as "...to promote awareness of differences and possibilities, and understanding of how things have come to be as they are and that they might have been otherwise. It must be used to enlarge horizons, to shake complacency, to stir the imagination" (Barrow, 1980, p. 83).

This understanding will help to produce citizens who are well informed about the bio-physical environment and its relationship to their society; who understand the roots of the ethics and moral philosophies that guide human behaviour, who know their natural position in the living community, and who understand the human impact on the ecosystem. Producing such citizens is not, however, an easy task. The successful teaching of ecohistorical information requires a particular instructional approach. Such instruction should promote understanding, reason, and evidence, and while a familiarity with actual historical facts and events is obviously important in developing ecological awareness, an analysis of those facts is equally important in order to derive the knowledge of circumstances and consequences that might affect the future of world ecology. While I strongly advocate using historical material to this end, I recognize that, as both Klopfer (1969) and Russell (1981) point out, it may be a difficult challenge.

One might argue that historical information related to the environment should be included in history books, and that agricultural and geographical historians should have a better knowledge of documentary sources. But first, as Sheail (1971) pointed out:

> Unfortunately, the historian and geographer, in their turns, have frequently ignored wildlife in the past, and wild animals have received scant attention in their writings. In the fifteenth and early sixteenth centuries, larger tracts of arable land were turned into sheep pasture, and the grazing grounds of our zoo villages were extended. This change in land use has been closely studied by historians, but no one has mentioned its likely impact on wild life. (p.158)

Second, even if historians paid attention to human impact on past wildlife, it is ecologists who can reconstruct the landscape of the past more realistically by using ecological knowledge to understand the relationship of plants and animals to their habitat (Sheail, 1971).

A) What are the main objectives of ecohistory ?

Ecohistory relates to the broad goal of ecological education, which is to contribute towards the development of scientific and ecological literacy that includes: (1) stimulating and encouraging student interest and appreciation for ecology, and (2) developing an accurate understanding of the behavior of ecological systems and the impact of human behavior on these systems.

The main objectives of eco-history proposed in ecology-school-curricula (ESC) are:

1) To inform students' views of ecology, and stimulate their interest in it.
1) To stimulate students to move from being passive observers to being positive, appreciative participants in ecological and environmental issues.
3) To influence students' understanding of ecology by developing accurate images of past ecology.
4) To avoid perpetuating present destructive behaviours and attitudes toward the environment.

It seems, however, that the significance of ecohistory in achieving the broad goal of ecological education has been ignored by both scientists and educators.

B) What resources can we find for the study of the history of ecology?

Sheail (1971) suggests that the most important source of information on past environments, especially wildlife populations, is contained in old books and documents, such as letters and notes left by naturalists, landowners, farmers, and topographers. Information on past environments and the history of living things can also be generated from field studies and geological records. Plant and animal remains can be used to determine the vegetation cover of a given period of time and can help students to see how changes in climate and vegetation over time can alter the distribution of plant and animal species. For example, by using special techniques (such as pollen frequency, type, and characteristics), paleobotanists and archeologists are able today to analyze pollen remains to predict the involvement of prehistoric men and women in the modification of their environment (Flannery, 1986; Moore, 1986). So, teachers should be advised to communicate with archeological and anthropological departments in the universities and museums to utilize such information and to throw light on the subject. There are also current books and publications of historical ecology such as *Historical Ecology* edited by L.J. Bilsky (1980), *Ecology in Ancient Civilizations* by D. J. Hughes (1975), *Nature's Economy* by D. Worster (1987), and *Ecological Imperialism* by A. W. Crosby (1986), to name a few.

Sources can also be generated by studying the social behaviour of hunter-gatherer societies such as the Kung Bushmen of Botswana in the Kalahari Desert, the Netsilik Eskimo, or any of the native American Indian groups (such as the Kogi Indians of Sierra Nevada de Santa Marta). The social behavior exhibited in these societies reflects the struggle for survival within the specific environmental circumstances of each group. From them we can learn of the earlier history of modern societies, and how the environment was viewed during those times. For instance, it is believed that those societies have a high aspiration to live in balance with nature, and to treat the earth as a mother (Sitton, 1980; Sessions, 1983). Yet, some other prehistorical societies did otherwise (Diamond, 1988).

In ancient times, as well as in some present human societies, the realm of humanity and nature were intertwined in the human consciousness. Human beings did not separate themselves from nature. They believed that nature was populated by beings like themselves the spirits of water, fire, air, land, etc (Kirilenko and Korshunova, 1984). Because of this, nature and its forces were treated as living beings; thus nature was angry with them if there was a storm, a hail or drought; and they thanked the land for a rich harvest and the sky for long-awaited rain (Kirilenko and Korshunova, 1984). The behavior of birds, animals, insects, and even plants, was observed in order to forecast the weather. As time went by, humans learned how to use their hands to create tools and to develop means and techniques to manipulate the environment and to be independent from nature. As a consequence, nature began to lose its concrete impact in the consciousness of humankind.

Today, in the 20th century, it is evident that human beings in Western society have lost their unity with nature as a result of adopting new philosophies in their quest for knowledge, practical activities, lifestyles, etc. The dominant current philosophies see humans as being 'above' the natural world, which is for us to exploit and control -- a 'resourcist' view of nature (White, 1967; Livingston, 1981, Suzuki, 1986) It is important for students to know and understand why these changes took place in Western society, and the circumstances that led to such changes through the course of human history.

When looked at from an ecological viewpoint, the ruins of human civilizations and desert environments created by human beings can be good educational resources for ecohistory. Studying the ruins of human civilizations, and phenomena such as desertification and deforestation brings insight into how human beings have not developed a full awareness of their need for a protective as well as a productive environment.

The Alaska oil spill in 1989, the explosions of nuclear power plants such as the one near Chernobyl in the Soviet Union which shocked the world in 1986, the Three Mile Island nuclear disaster in the USA in 1979, or the mass gassing of Indians living near Union Carbide's Bhopal plant in 1984, would all be excellent historical sources to be used to inform students about the environment and the ecology of the world. The global nature of these disasters can be seen in the radiation from the nuclear calamity at Chernobyl having spread not just across northern Europe beyond Scandinavia into the North Atlantic, but also south into northern Mediterranean and even in to North America (Shnayerson, 1986). Other historical events such as the extinction of many plants and animals due to overhunting in North America and the contuning effects of volcanic eruption causing destruction of the basic food resources for many people are also important.

The history and development of environmental legislation and laws can also be used as a source of information. Environmental legislation usually serves primarily the major interests that dominate modern culture, which in American society is economic wealth and power (Keller, 1979). Teachers can discuss certain environmental legislation and laws and identify key issues, then try to relate these issues to the moral and ethical values of society toward the natural world. For example,

> It is emphasized that the English Nuisance Law of 1536 involved a type of common law still used in the United States, the main principle of which is that if other people suffer equally from a particular pollution, an individual can not bring suit against the polluter. (Keller, 1979, p.503)

The Refuse Act of 1899 stated that "...it is against the law to pollute any stream in the United States. However, the Secretary of the Army can allow the discharge of refuse into a stream if a permit is first applied for " (Keller, 1979, p. 508). The National Environmental Act of 1969 is another example with a difference. According to Keller (1979) "The act requires that before any environment-affecting activity that is directly or indirectly involved with the federal government can begin, a statement evaluating the environmental impact must be completed" (p. 521). These examples show the possibility of using the history and development of environmental legislation as a source of information in ecohistory because they reflect whether or not society considers the possible long-range injury caused by human activities. They also reflect the strength of the public's concern not only for our survival and welfare, but also for that of our children and of our children's children.

C) Which themes in ecohistory are most important for the attainment of ecologically educated minds?

With respect to the history of ecology, it is worthwhile for students to know something about:

1) The history of the planet on which we live; theories of its origin and the development of life upon it.
2) The history of reginal faunas and floras; their origin, evolution and distribution.
3) The history of our species; its origin and evolution.
4) The history of human civilizations; their origin, distribution, and decline.
5) The historically documented changes in the human environment (our own historically documented modifications of the environment), including the impact of the industrial revolution; new technological energy from coal, to oil, to nuclear power; the growing of world populations; the pollution of air, ocean and land; etc.[1]

The interrelationships of the above themes, set against the background of ever-increasing human population, are the keys in developing improved human attitudes and behaviour towards the environment. It is the conflict between environmental problems and economic, political, and social benefits that becomes the critical factor in ending environmental deterioration.

There are considerable grounds for believing that the present values and morality of humans stem from ecological ignorance. It would reasonably follow that any understanding of ecological damage is vital to an understanding of human values and morality. Aldous

[1]-See Cherif (1988) "History and Ecological Education: A way of understanding ecology in secondary school education", American Biology Teacher, Janury 1988. But to consider one example, one might suggest the following history of specific themes to be studies in category 5 "The historically documented changes in the human environments"

1). Ecological shifts caused by over cultivation and grazing(Desertification).
2). Ecological shifts caused by logging (Deforestation).
3). Ecological shifts caused by mining (Erosion).
4). Ecological shifts caused by contaminating (Pollution).
5). Ecological shifts caused by hunting and fishing (Extinction or De-diversification).
6). Ecological shifts caused by cultivating (Salt depletion,Erosion and Pollution of water).
7). Ecological shifts caused by the conflicts between the environment and political, economic, or social benefits (Ecological crisis/ Resource conflicts).

Huxley, one of the first to warn of the impending environmental crisis, wrote in his novel "Island" (1962) that:

> Confronted by [examples of ecological damage], it's easy for the child to see the need for conservation and then to go on from conservation to morality--easy for him to go on from the Golden Rule in relation to plants and animals and the earth that supports them to the Golden Rule in relation to human beings....The morality to which a child goes on from the facts of ecology and the parables of erosion is a universal ethic....Conservation morality gives nobody an excuse for feeling superior, or claiming special privileges.(Cited in Sessions, 1983, p. 35)

An understanding of the problem of desertification in North Africa may help Canadian students to understand the horrifying potential of long-scale deforestation in Canada. Not long ago North Africa had a rich flora and fauna. It once supported a much largger population, and exported wheat, olive oil, and other agricultural products throughout the Roman Empire and during the later Islamic civilization (Bagi,1983). Today, this same area possesses the largest human-made desert, the Sahara. Students need to know that this happened through the introduction of foreign animals such as goats and sheep, and the development of new behaviors such as wood-gathering. The massive deforestation presently occuring in some parts of Canada due to over-logging, and without any concerted efforts at replanting, presents a comparable long term prospect. By teaching Canadian students about desertification in North Africa, and the over-logging of cedar forests of Lebanon and Greece in early times, they may realize the danger of the over-logging that is presently taking place in their own land. By extension they can also realize the need for humankind to be fully aware of the necessary conditions for a protective and productive environment.

History has shown us that scientific methodology alone cannot guarantee a true explanation of biological or ecological questions and phenomena. Greater use in the teaching of historical and philosophical aspects of biology can provide an understanding of such scientific processes (Hill,1986). Likewise, an understanding of current ecological problems can be enhanced through the study of similar problems in the past, and by examination of the relationship between social changes and the shifting relationships within the environment in any given society (Bilsky,1980). There is a question as to how much historical material is needed for these purposes. Russell (1981) asserts that "If we wish to use the history of science to influence students' understanding of science, we must include significant amounts of historical material and treat that material in ways which illuminate particular characteristics of science" (p. 56). The question of how much is a "significant amount" might remain a moot point for years to come. In the meantime, it is crucial that we get started.

Basic Fundamentals of Ecology

With all the information and the amount of scientific knowledge that is now available, the selection of what needs to be taught in a given classroom becomes more critical than ever. Children need to learn basic ecological principles and concepts, but they must go hand in hand with the process as 'a means' to understanding, not only the facts and theories, but also the source of the information, how it was derived, and how to relate it to one's current knowledge and life in general. In order to grasp fully the basic fundamentals of ecology, students should learn and understand at least the following: (1) the laws of ecology (interdependence of all life, species diversity, limitations of natural resources); (2) the structure of an ecosystem; (3) the mechanisms of ecology; and (4) mathematical ecology. These topics reflect sufficient ecological principles and concepts to provide a basic background in ecology. They are also necessary to generate field work, which is essential for an accurate understanding of the relationship between organisms and their environment. While all these themes exist to a greater or lesser extent in most secondary school biology textbooks, it is the way they are presented that is the issue here. With this in mind, these themes with the exception of the structure of an ecosystem which has been adequately covered in most biology textbooks, will be discussed in the following section. I want to emphasize the normative issues, concentrating on what ought to be taught under these themes.

1. The Laws of Ecology:

The basic laws of ecology which hold true for all forms of life--from simple unicellular organisms to more complex multicellular organisms-- can be grouped for instructional reason into the following three ecological principles: the law of interdependence; the law of diversity; and the law of limitations of natural resources. One of the reasons we must understand these laws is that

> These laws, just like our own laws, restrict our freedom of conduct and choice. [but] unlike our laws, the laws of nature cannot be changed by legislative fiat; they are imposed on us by the natural world. An understanding of the laws of nature must therefore inform all our social institutions. (Hunter, 1988, p. 316).

Failure to do so, simply means we choose death to our species and the whole planet Earth because we no longer can get around these laws (cf. Hunter, 1988).

a). <u>The Law of Interdependence of All Life</u>

All species living in a given ecological community depend on each other for survival. Every ecological community contains a complex set of biological interrelationships. There are no single linear relationships between organisms. Studying the interrelationships between the organisms in a given community provides us with invaluable information on the flow of energy and chemical elements through organisms (Emmel, 1973). Biological, cultural and social evolution of a given species depends on the stability and the harmony of this interdependent relationship between organisms.

Humans are a part of this relationship as members of biotic communities and ecosystems despite their present dominance over the earth. They still depend totally on the interactions among other species in the biosphere for their continued existence (Dasmann,1976). To illustrates human's position in this interdependence of life Dasmann (1976) wrote:

> If one lives in a city, it is sometimes easy to forget this dependence and even to assume humanity has risen above nature. But the bread you eat comes from wheat plants formed of soil, air, and sunlight. The soil, with its hosts of microrganisms to maintain its health and fertility, was itself formed by the works of generations of green plants and animals, transforming rock and sunlight energy into the organized network of materials needed for the growth of wheat plants. The meat people demand in their diet also comes from soil materials, transformed by a great community of grassland organisms into the plant protein and carbohydrate needed to feed a steer. Beef is soil and sunlight made available to us by the work of plant communities. Like all other animals we depend on the interrelationships of living things with their physical environment. (p.14)

While what Dasmann says is not new, it is definitely something that has often been ignored by humans due to lack of ecological consciousness. Humans, therefore, must be educated to be aware of this interdependence[1].

b).The Law of Species Diversity

Diversity is necessary for life. It is directly related to the structure and function within a given system. This correlation is what maintains life and gives stability to a given system. The more diversified the species in an ecosystem, the more resilient it will be to change and disruption. The following quote clearly illustrates the biological and ecological significance of diversity for the stability of any ecosystem.

> Very simply, a highly diverse system is composed of many species, each more or less equally represented. In contrast, a system lacking diversity has few species with as few as one species accounting for most of the individuals. Thus, one can picture a diverse system as being more balanced, with no species playing a dominant role and the energy in the system being supplied equally to a variety of different species. A great deal of "information" can be said to exist in such a system. If one species falters, many others are available to assume its function and little loss of efficiency in the total system is suffered. On the other hand, a simple system lacking diversity is relatively unbalanced. It operates according to the functions of a few species (perhaps only one), and if the dominant species falters, the efficiency of the whole system suffers. Such a system has little 'information' from which to operate and provide resilience to environmental stress. (Christman, et. al, 1973, p.32)

1- Ecological consciousness means understanding the complex web of ecological interrelationships between all forms of life on the earth, and an appreciation, both esthetic and intellectual, of the diversity of organic assemblages around the world (Emmel, 1977)

Every ecosystem is able to maintain its own diversity and, in turn, its life, through this dynamic-evolutionary process. Existing species become extinct at approximately the same rate as new species evolve. Today however, overwhelming evidence exists to show that this equation is becoming increasingly lop-sided (Roush, 1982). On-going destruction of the diversity of species in the ecosystem as a result of human activities to conquer the natural environment has increased at an alarming rate. Humans have forgotten that human life evolved, and flourished for thousands of years, in an environment filled with an extraordinary diversity of species. Instead of maintaining a high natural diversity, human kind has chosen ways leading to the destruction of the diversity of species which in turn leads to the destruction of the environment.

Diversity is important for the development of ecological ethics among people. It has a historic mission beyond just mere survival, breeding, or physiological continuity in the human community. Beside its biological significance, diversity promotes the development of an attitude where individuals advocate what is good, demand what is right, and eradicate what is wrong[1]. Furthermore, diversity discourages people from establishing communities founded on race, nationality, occupation, kinship, or special interests. The whole community is an organic entity and every individual is an equal member regardless of his/her differences (the essence of a true democracy).

Understanding and respecting the reality of natural diversity and its importance for the whole natural ecosystem illuminates human understanding toward peace, freedom, human rights, and interdependence in nature. People who abuse the natural diversity of their surroundings in the interest of their immediate needs violate the rights of a great many people and animals, and disrupt the peace and freedom of others. For example, Roush (1982) explains that:

1.- By right I mean Aldo Leopold's meaning of right which is that, "A thing is right when it tends to preserve the integrity, stability , and beauty of the biological community. It is wrong when it tends otherwise".

> If a farmer drains a marsh in order to replace its abundant diversity with a monoculture empire of soybeans, then quite possibly he has done me some ecological harm. I am entitled to ask by what right he does so and why his rights should supersede mine. If, in addition, the soybean industry happens to extinguish a species or two, it has denied the rest of us an irreplaceable genetic resource. The eradication of an element of diversity can be a violation of the rights of a great many people. (p.8)

Furthermore, a stable and beautiful biotic community is needed for our own sanity and well-being. Regarding this sanity and well-being Roush (1982) wrote that:

> Human beings seem to have an innate need for natural diversity, and to be deprived of it pains even the staunchest lover of cities, consciously or unconsciously--Any natural place that people call beautiful is almost certain to be a diversified healthy ecosystem, whether it be a marsh, prairie, desert, or an alpine meadow. [Therefore] When people talk about going to 'the country' for a vacation, they do not mean simply getting out of town. They mean finding some version of diversity--People need a holistic, organic perception of their milieu and their place in it. Prolonged monotony of any sort produces neurosis, for which cultural and natural diversity are the only effective defenses. (p. 8).

The reading and thought that went into this section (species diversity) serves to justify one of the objectives of ecology education, which is maintaining global biological diversity.

c). Limitations of Natural Resources

All natural resources in a given ecosystem are limited. This means that every organism has a limited capacity for activities and growth. Acting beyond this limitation will disturb the harmony and stability of other elements in the ecosystem. In turn, this could lead to a state of imbalance within the biosphere. The exponential population growth (Logistical curve) makes increasing demands on the natural resources. This is clear from tropical deforestation caused by growing cash crops and raising cheap beef for industrial countries.

Currently, energy resources, whether renewable or non-renewable, are beginning to cost more and appear to be nearing their limits as determined by the laws of thermodynamics (Cook, 1980). If humans keep neglecting the remaining natural resources, there may be little hope for creating peace, harmony, freedom, and the right-to-life ethic on this planet. Indeed, because of habitat destruction by human settlements and management practices particularly with respect to human needs (Jacobs,1981), the struggle for energy is increasing, not just between communities and societies, but also between species and individuals . Humans have forgotten (if they ever knew) that they have not inherited the earth from their fathers, but they are borrowing it from their children. In short, with a world population that is increasing rapidly, an understanding of the limitations of natural resources in the light of this population growth becomes critical.

2. The Mechanism of Ecology:

To grasp the mechanism of ecology, students should learn and understand the ecological succession, food chains and food webs, dynamic motion of biophysical, environmental, and energy and biogeochemical cycles. This understanding will encourage human beings to develop a sense of responsibility for the wise use and management of the natural resources--one of the aims of ecology education.

a). Ecological Succession

It is well recognized that biotic communities seldom remain the same for very long. The continuing activities of a community lead to changes in the environment, often making it less favorable for its own members. Such changes make the environment more favorable for the entry of new species while the old ones find conditions less favorable and must move or die out. Eventually, even new species which replaced the old alter the environment in their turn. This process of gradual and continuous replacement of one living community by another is known as ecological succession[1].

Ecological succession is one of nature's most dramatic and important biological regulators in the development of the over all ecosystem. Understanding the principles of

[1]- Succession is sometimes described by the phrase, "ecosystem development "(Odum, 1975), or "evolution of the ecosystem toward high diversity (Kormondy, 1976).

ecological succession and human impact on its developmental process are, therefore, of the greatest importance to humankind if a rational working balance between humankind and nature is to be achieved(Odum, 1975).

The Importance of the principle of Ecological Succession: An understanding of the concept of ecological succession is central to the development of an ecologically informed citizenry and should always be a part of ecology education. The rationale for its inclusion is as follows:

1. Integration: Ecological succession illustrates how ecological principles and concepts often studied separately become integrated in real life. This can be demonstrated by a single dynamic model of ecological succession in the field (on the large scale), laboratory (on a microcosm scale), and in the classroom (as a class ecological exercise). In such exercises, students can see much more vivdly the nature of the interaction and interdependence of individuals with each other and with their environment. This opportunity for observing dynamic changes is an advantage many other ecological activities lack.

2. Ecological succession for an Informed Citizenry: Ecological succession is the reason that weeds must be constantly removed from crop fields and in some cases from recreational areas and lakes. Lake Tahoe in California for example is kept at an early and immature aquatic successional stage for the purpose of recreational use by removing aquatic weeds. The same has become true for Okanagan Lake with removal of Milfoil. Ecologically speaking, this means they are maintained in a condition of low diversity by the application of continued costly labour. In general, humankind often tries to maintain desirable but successionally unstable communities without realizing that, "succession is inevitable in most aquatic and terrestrial communities" (Sutton and Harmon, 1973). This process continues even in mature ecosystems and in areas with a stable climate.

Ecological succession teaches us that the environment (especially where it involves mature climax systems) must be considered not only for its economic value (e.g., as a source of food), but also for its long term value under a policy of multiple use. Ecologically speaking, this requires that human beings maintain both primary and secondary succession in order to have both a protective and productive ecosystem. Civilization has already paid for ignoring ecological principles such as these. Odum (1975) wrote that, "Ruins of civilizations and man-made deserts in various parts of the world stand as evidence that man has not been fully aware of his need for protective as well as productive environment"(p. 164). Furthermore, according to Odum (1975),

> Man must have early successional stages as a continuous source of food and other organic products, since he must have a large net primary production to harvest; in the climax community, because production is mostly consumed by respiration (plant and animal), net community production in an annual cycle may be zero. On the other hand, the stability of the climax and its ability to buffer and control physical forces (such as water and temperature) are desirable characteristics from the viewpoint of the human population. The only way man can have both a productive and a stable environment is to ensure that a good mixture of early and mature successional stages are maintained, with interchanges of energy and materials. Excess food produced in young communities helps feed older stages that in return supply regenerated nutrients and help buffer the extremes of weather (storms, floods, and so on). (p. 163-4)

Thus the principle of ecological succession "...provides important natural guide-lines for determining options and making decisions as to how to make optimum use of the total environment" (Odum ,1975, p. 165), and yet maintain its components and productivity.

3. When ecological succession is viewed in terms of energy flow within a given ecosystem, it shows us the continuing need for high species diversity, large long-lived population organisms, many available niches, and many complex food webs. In addition, all tissue growth and other organic materials must be consumed in order to maintain the ecological balance in a given ecosystem (Sutton and Harmon,1973). In other words, high total biomass, organic matter, and complex food webs must be available in a climax community to maintain ecological balance.

4. Studying the processes of plant succession can enhance the understanding of the need for a new relationship between mankind and the natural world. When "pioneer" plants multiply and use up the resources in a newly occupied site, the given site becomes unsuitable for further occupancy by the pioneer plant species. In this case, other better adapted species will come and take over. Human behavior has been compared to the stages of plant succession, especially the pioneer plants. According to Clarke (1973) such a comparison has value as an "...illustration of alternative ways of living that have different consequences with regard to long-term survival. Most human communities either do, or else want to, exist in something like the state of pioneer plants: rapidly expanding in numbers while exponentially expending the environment's accumulated materials" (p. 282-3). Unlike plants, however, humans import other materials, especially energy, from different places, and therefore consume more than they produce. The danger here is that this "...parasitism on other areas, which is coupled with the pollution of the common terrestrial environment" (Clarke, 1973, p. 283), is tolerated and even encouraged because it is economically 'cheap'. Then the vast amount of waste is spread evenly over the globe so as not to be noticed. According to Clarke (1973) while such an operation may be 'economically sensible' it is definitely 'not ecologically sensible' because in the long run, all of us must pay. We are polluting our world...and all costs are internal" (p.283).

While succession has been taught in many biology classes at secondary school and college levels, too often is taught only as factual knowledge. It needs to be taught also in terms of its implication for the quality of human life and the stability of the human ecosystem. Providing such examples and their wider implications as illustrated above, gives a better understanding of the inevitable continuing role of succession in our daily lives as well as its significance for social and ecological stability.

b). Dynamic motions of the biological and physical environment

The biosphere itself is in a dynamic evolutionary process which reaches from the individual organism, through energy flow and material cycles, to the total cosmos. This dynamic-evolutionary motion creates change and new requirements for survival as time goes by. The ability of a given organism to adapt to this process is what maintains the form of the organism. Schmookler (1984) states that:

> The survival of life forms depends on their ability to integrate into an evolving environment. The main characteristic of their process is not competition between species, but is the ability of the organism to integrate or fit with a particular ecological niche. This would also be true for human society, even with our ability to modify our environment [and the role which we play within our community]. (p.10)

The flow of energy and mineral nutrients and the cycle of materials keeps nature in a state of dynamic change. Through these flows and cycles, there is a continuous process of exchange in materials and energy. Organisms depend on each other for these materials and energy through food chains and food webs. In fact, all elements (including living organisms) of any dynamic process depend on each other; for example, the "Carbon cycle" in an ecosystem. We must keep in mind that in nature, almost everything is reused or recycled as one of the mechanisms for the maintenance of ecological systems and the existence of life. We must learn to adopt and maintain these fundamental cycles in our activities, rather than carrying out activities that disrupt the flow of energy and nutrients in nature.

c). Energy and Biogeochemical Cycles

Understanding the laws and mechanisms of energy flows and material circulations in a natural ecosystem will encourage humans to understand and be responsible for wise use and management of the natural resources, which is one of the aims of ecology education. Energy flow and material circulation in a given ecosystem have the same effect on adoption, diversity, number, and growth rate of organisms as do many other aspects such as the magnitude of available energy and resources, geographical locations, evolutionary history, etc. (Odum, 1975). Since the one-way of energy flow and the circulation of materials apply equally to all environments and all organisms including human, Odum (1975) describes them as the two great principles or "laws" of general ecology. He wrote:

> ... it is the flow of energy that drives the cycles of materials. To recycle water nutrients, and so on, requires energy which is not recycleable, a fact not understood by those who think that artificial recycling of man's resources is somehow an instant and free solution to shortages. Like everything else worthwhile in this world, there is an energy cost. (Odum, 1975, p.61)

Understanding the characteristics of, and the relationship between, the flow of energy, the water cycle, and the biogeochemical cycles are some of the obvious objectives of ecological education.

Energy flow : Many, if not all, of the processes in nature involve the transformation of energy from one form to another (both natural and artificial processes) (Ehrlich, Holdren and Ehrlich, 1980). Indeed, energy flow is one of the fundamental biological concepts inherent in food chains, homeostasis, and metabolism. Few biological questions can be defined or addressed without mentioning energy (Schumacher, 1973). Indeed, "without the input of energy from the sun, life could not exist; the movements of air and water in the atmosphere are driven by this source, and even non-renewable resources of a geological nature have been formed as the result of solar energy" (Simmons, 1974, p.67). Thus, a grasp of the principles and concepts of energy transformation is essential for the understanding of any environmental problem. It is very important that our young citizens are aware of the importance of ecological energetics and their much wider implications (Aston, 1978).

Energy transformation is governed by the laws of thermodynamics and, therefore, understanding these laws and their basic ecological implications are necessary for understanding the environmental problems and their effect on nature.

The first law of thermodynamics, which deals with the conservation of energy, says that energy in a closed system can neither be created nor destroyed but only changed from one form (such as light) to another (such as potential energy food). But if the energy must always balance, one may ask, "how can we become worse off, if the amount of energy never diminishes?" Ehrlich, Holdren and Ehrlich (1980) address this question:

> One obvious answer is that we can become worse off if energy flows to places where we can no longer get at it, for example, infrared radiation escaping from the earth into space....A far more fundamental point, however, is that different kinds of stored work are not equally convertible into useful applied work. We can therefore, become worse off if energy is transformed from a more convertible form to a less convertible one. (p.45)

The second law deals with the tendency of energy to become dissipated in the universe. It states that some useful energy (that is, energy-work availability) is converted into heat energy at every transformation of energy. Thus, any work involves the escape of energy in the form of heat energy into the surrounding environment. Ehrlich, Holdren and Ehrlich (1980) state that:

> In many processes, for example, the availability of energy in some part of the affected system increases, but the decrease of availability elsewhere in the system is always large enough to result in a net decrease in availability of energy overall. What is consumed when we use energy, then, is not energy itself, but its availability for doing useful work. (p.46)

Our students should understand that if some useful energy in the biological and physical world is converted into heat energy at every transformation, then more energy must be supplied to and used in a biological system from outside the organism to counter-balance the inevitable loss of energy as heat. Thus, a given organism must continuously receive new supplies of energy from the ecosystem to maintain its functions.

The ecological lessons we can learn from energy flow and the laws of thermodynamics are:

1. There are fixed limits to technological innovation, according to the fundamental laws of nature (Erhlich, Holdren and Erhlich, 1980).
2. The solutions to the complex ecological and energy problem Strickland and Staner (1979) argue do not lie in technology alone, "...but in an alteration of human behaviour." They add."Mankind must begin to realize that each act upon

the environment results in many different reactions which are often unexpected and have catastrophic results" (p.249).

3. Energy used once by a given organism or population Odum (1975) explains, is converted into heat; in this degraded form it can no longer power life processes and is soon released from the ecosystem. (p., 60).

This means that all living organisms like all machines can only be kept going by the continuous inflow of energy from the outside (Odum, 1975).[1]

Biogeochemical cycles: The dynamics of life processes depend not only on energy, but on the availability of some thirty-four elements. Living organisms require these elements for normal development either in abundance or small amounts (Kormondy, 1976). The continued availability of these elements depends on some cycles that lead to the re-use of the elements. The transformation and circulation of these different elements from the earth through living systems and back to earth is called biogeochemical cycling. In other words, "without life, the biogeochemical cycles would cease, and without the biogeochemical cycles, all life would cease" (Sutton and Harmon, 1973, p.125). This is simply because biogeochemical cycles help retain necessary nutrients in usable form for the organisms and help maintain the steady state of the ecosystems (Emmel, 1977). It is therefore, ecologically important to consider the transformation and circulation of the most important of these nutrients in ecosystems, and subsequently to consider the effects which result from human's inadvertent or purposeful interaction with them (Kormondy, 1976).

The most important of these elements involved in the origin of life, and which compose most of the mass in living organisms, are carbon (C), hydrogen (H), oxygen (O),

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[1]-Ehrlich, Holdren and Erhlich (1980) wrote: "More generally, the laws of thermodynamics explain why we need a continual input of energy to maintain ourselves, why we must eat much more than a pound of food in order to gain a pound of weight, and why the total energy flow through plants will always be much greater than that through plant eaters, which in turn will always be much greater than that through flesh eaters. They also make it clear that all the energy used on the face of the earth, whether of solar or nuclear origin, will ultimately be degraded to heat. Here the laws catch us both coming and going, for they put limits on their efficiency with which we can manipulate this heat. Hence, they pose danger--that human society may make this planet uncomfortably warm with degraded energy long before it runs out of high-grade energy to consume" (p.47-48).

nitrogen (N) sulphur (S), and phosphorus (P). In ecosystems, these elements are cycled back for reuse and their movement through the atmosphere, hydrosphere, lithosphere, and biosphere must be maintained in equilibrium. Thus, when one or more of these nutrient elements are taken out of the recycling mechaism of their natural systems, the reqirements for the stability of the ecosystem and its component members would be hampered or destroyed. A totally different balance point involving substantial changes in species composition will be established.

Humans, over a long period of time, can push a given ecosystem out of its natural equilibrium by increasing the input of a particular nutrient. Christman, et. al, (1973) state that:

> Man can seriously upset the rhythm of ecosystem nutrient cycling on a large scale either by inflicting direct mortality on less tolerant species, or by slightly changing the environment so that these species are lost in the natural selection process. Both accomplish the same end; only the time required is different. (p.35)

Biogeochemical cycles can be divided into three basic types: The hydrologic cycle, gaseous nutrient cycle, and sedimentary nutrient cycles. While the elements of gaseous cycles represent only ten percent of the forty or so elements essential to living organisms, they constitute about 97.2 percent of the bulk of living organisms. Sedimentary nutrient cycles constitute 2.8 percent of plant and animal tissues, they tend to go downhill in terrestrial ecosystems (Emmel, 1977). These cycles are slower than gaseous nutrient cycles and tend to exert a more limiting influence on living organisms (Sutton, and Harmon, 1973).

The importance of the hydrologic cycle to ecology has been stated clearly by Kormondy (1976) when he says that:

> The ecological significance of water is [that] in addition to its obviously important role in constituting some 70 percent of the weight of organisms, it is the significant medium for biological activity. Further, it is an agent of geological change, eroding in one place and depositing in another. It is thereby an agent of nutrient distribution, a role which is augmented by the great variety of chemicals it carries and dissolved salts and gases. Finally, but of fundamental significance to ecosystems, is water's role as an agent of energy transfer and utilization.(p.42)

There is no fear that our planet will run out of water. Human life, however, can be jeopardized because the quality of water has been seriously affected by humans' vast pollution of almost all the fresh and salt waters of the earth. This will represent a serious problem because, "...life evolved as a result of a physical and chemical environment whose quality has remained relatively constant for billions of years" (Christman, et. al, 1973, p.35).

Therefore, it is critical that students understand the relationship between the flow of energy and the biogeochemical cycles. It is also important that they understand how elements cycle through the biotic components of an ecosystem as well as the relationships between the three types of cycles; hydrologic, gaseous and sedimentary cycles and their interactions with the ecological processes.

4. Mathematical Ecology:

Because ecology education involves field-work, a true connection with the environment through first-hand experience can be achieved, and, as a consequence, awareness and understanding of ecological systems obtained. Since field-work very often involves the collection of data about the species and their populations in a given community, then the problem remains (for both students and teachers) of what to do with such data; how to translate them into diagrams, charts, graphs, and tables, which can then be interpreted as useful knowledge. This is one of the aims of mathematical ecology.

The rationale for using math in teaching ecology at the secondary school level is that if possessing "...mathematical skills increases the students' competencies in solving science problems" (Friend, 1985, p. 454), then the inclusion of mathematical questions and numerical problems in teaching ecology might increase students awareness about environmental issues which could ultimately lead to direct action. After all, "...quantifying data is the most effective way to convince the decision makers, and...math measures the interactions of the parts of the environment" (Railton, 1987, p. 77).[1] Because of this, many students find it useful to employ mathematical processes in order to describe and explain a given natural phenomena scientifically.[2]

The argument is that one effective way for students to become aware both of environmental problems as well as the way these problems might be reduced, is through relating mathematics to environmental issues. By using mathematical concepts and techniques, students could gain an understanding of environmental threats and the means of their avoidance (Schwartz, 1986). The aim of mathematical ecology should be to teach students not only how to calculate and obtain a numerical answer but also how to evaluate the significance of their answers. This means that the knowledge, concepts, and techniques they gain should help them understand the environmental implications of current events and decisions at the local, national, and global level.

It may be argued that mathematics is best be taught through the discipline of mathematics. This may be true. But for the following six reasons, I see mathematical ecology as being of significant importance in teaching students about environmental issues and trends.

First, I am not suggesting that mathematical ecology should cover a smorgasbord of mathematics such as set theory, logic, number theory, or even advanced statistics and probabilities. All the students need are concepts and techniques for doing basic computations, percentages, ratios, tables, circle charts, maps, and graphs. Activities such

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1- Mathematics has become " one of the powerful instruments which helps to integrate into a single whole the great range of knowledge in all its diversity" (Chepikov, 1977, p. 83).

2-The need for adequate integration between science and mathematics education has already been recognized by many professionals in the field (e.g., Railton, 1987; Friend, 1985; Pratt, 1985a; 1985b; Buccino and Evans, 1981; McGarvey, 1981; Chepikov, 1977; Dudley, 1975). Perhaps with such integration, students will be able to demonstrate increased cognitive development (Friend, 1985; Kolodiy, 1984). As the situation now exists, there is no consistent pattern of mathematics usage in secondary science textbooks (Pratt,1985b). Buccino and Evans (1981) believe that the lack of integrated instruction within and between subjects and disciplines of science and mathematics is one of the most serious contemporary problems facing leading mathematics and science educators. Therefore, concerned educators argue that integrating science and mathematics instruction would be helpful for science students. It would also be helpful for teachers who would like to adapt inquiry approaches which emphasize student-centered instruction and an integrated problem-solving strategy (Pratt, 1985b).

as these involve important math skills not always learned in the mathematical context. Skills such as these are important in illustrating environmental issues like population growth, rate of population change, balance growth, net migration rate, body size, wastefulness, and resource demand. They are also important in determining, for example, relative humidity as well as the ecologically important values which require first calculating frequency, relative frequency, density, relative density, cover and relative cover. They important too in determining energy input and output in disturbed, relatively disturbed, and undisturbed ecosystems as well as to quantify niche (breadth and width) measurements[1]. Such calculations are an educational challenge for students to evaluate various environmental aspects (physical, biological, social, and cultural) with respect to their ecological compatibility where, in turn, might lead students to understand what kind of impact their choice of lifestyle and energy consumption has on an ecosystem (Silvius, 1984).

Nevertheless, there is evidence that secondary school students who have the opportunity to conduct some kind of ecological field-work, encounter certain difficulties. Among them are: 1) the amount of time they need to observe objects and to collect data accurately, and 2) the complexities of recording and translating the data into diagrams, charts, graphs, and tables. If this situation does exits, then, mathematical ecology can be seen as the way to overcome these problems.

Second, there is evidence that mathematics teachers rarely relate mathematics information and concepts to current critical issues such as the environmental crisis or other social problems at the grade-school and high school level. Instead, students tend to be discouraged by an array of meaningless mathematical examples (Folkenberg, 1986; Frankenstein,1983). Frankenstein (1983) argues that traditional math courses use no real - life data and thus they are useless for helping people understand themselves and the real

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1- Niche breadth is defined as the range of environmental conditions used by a species, while niche width is defined as the range of resources that a population utilizes.

world. Furthermore, according to Dr. John A. Dossey, President of the National Council of Teachers of Mathematics in the United States, many math teachers simply do not know how to teach math in grade school. He adds that:

> Failure is more apparent in mathematics than other school subjects because teachers often teach only one way to solve a problem rather than a variety of ways to solve a problem....Math teachers should communicate the principles of mathematics-the ways of thinking-which can be transferred to different settings. (Cited in Folkenberg, August 31, 1986, p. 5 C)

Moreover, in biology, within which ecology teaching exists in secondary school science, Pratt (1985b) found that there is a less diverse and only a minimal amount of mathematics representation compared to any other of the sciences (physics, chemistry and earth science). Indeed, he adds "the mathematics in traditional biology was not much different from that in non-traditional biology" (p. 402).

Fourth, the lack of relevance of mathematics to critical problems often leads to student apathy toward mathematics courses and hence missed opportunities for making students aware of environmental and other social problems. Indeed, by integrating environmental problems with mathematics topics, it may be possible to avert the questions frequently heard from students in mathematics classes such as, "Why do I have to learn mathematics? What is it good for? How will I use it when I get out of school?" (Schwartz, 1986 p.32).

Fifth, by relating mathematics and environmental issues, many students might adopt national and global perspectives in their conversations with family and friends. Frequently, these new perspectives help many people to understand environmental implications and to develop new environmental consumption attitudes and patterns. Furthermore, in using interesting and significant mathematical information, concepts, and techniques related to environmental issues, a host of environmentally related questions can be raised, such as "How serious is the population explosion? What are the economic, social and health costs of pollution? What are the environmental consequences of waste in the United States and other affluent countries?" (Schwartz, 1986 p. 31).

Sixth, a mathematically illiterate populace lacks an important tool necessary for understanding the real world and heightening an awareness of global living conditions (Frankenstein, 1983). Such unenlightened people may never find out whether math in a given argument is misused to make valid arguments. Those people could be led to believe that the tons of nitrogen oxides and sulfur dioxides daily spewed from the industrial midwestern states of the U.S.A. or from European industrial centers (such as in England) do not have anything to do with the ecological damage caused by acid rain and acid fog in Canada and parts of the northeastern United States and in Scandinavian countries. Such people can be easily deceived.

A mathematically illiterate populace might also find it easy to believe that there is no relationship between the profits of some chemical cooperations and the pollution of the natural environment or the suspected cancer-causing substances found in our environment. Or, for example, they could be led to believe that because large human populations cause disruptions in energy resources, the 'over-population' problem in global terms exists only in China, India, or other developing countries but not in the affluent industrial societies. Without the proger tools they are not able to research the numbers to find out that the total population of all these three countries might not consume even ten percent of the world's energy[1]. Lack of mathematical knowledge and skills could also prevent people from understanding how, for example, the U.S.A. is the most over-populated country in the world, based on the amount of resources required each year for each person. Such a realization requires people with, not only the ability to calculate, but also with the "ability to reason quantitatively, the ability to use numbers to clarify issues and to support or refute opinions" (Frankenstein, 1983, p.13) and decisions; in other words, having thinking skills and the ability to use them critically. Yet, as previously stated, school mathematics are far

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[1]- According to Sutton and Harmon (1973) "Thirty percent of the world's population (the industrialized people) consume some 80 percent of the world's energy. The United States, with only 6 percent of the world's population, accounts for 35 percent of the world's energy consumption!...The average U.S. citizen directly or indirectly uses about 200.000 C per day while most people in the world consume energy at just barely over the food intake level of 2.000 C per day."(p. 81-82)

from being related to actual people, life, and the real world (Frankenstein, 1983). Other relevant examples would show that some ecological concepts such as "carrying capacity" can be best understood only through math and numbers.

On some fronts the situation is improving. Mathematics has already found its way into experimental ecology. Today, complex mathematical models have become common tools of ecological research at the college level (Peters, 1983). Mathematical methods, analysis, and modes of thinking have already been applied to different sorts of knowledge; physics, chemistry, biology, geography, economics, history, sociology, etc., are utilized not only in research and higher education, but also in school education. As an example, today, mathematics' methods and modes of thinking are playing an important role in the modelling and describing of many biological phenomena and processes. Mathematics has enabled biologists "to tackle fundamental biological problems and to discover substantial connections between various phenomena and processes in living matter" (Chepikov, 1977, p. 122-123). In the field of "Biocybernetics" (one of the many interesting areas of knowledge in which ecology teachers might get help in integrating math into science) living organisms are regarded as "complex dynamic systems all of whose components are connected with each other, while an organism as a whole is connected with the external world" (Chepilov, 1977,p. 124). Biocybernetics is the branch of biology whose origin" is connected with the interaction among a set of sciences: cybernetics, biology, molecular biology, physics, chemistry and of course, mathematics" (Chepilov, 1977, p. 124).

For now, biology and ecology teachers at the secondary school level might find enough ready- made mathematical formalisms in mathematical courses as well as in natural and social science courses. However, it is also important for teachers and ecology educators to apply mathematics in order to foster student understanding of ecological systems. The application of existing mathematical methods might require modifications which can be achieved with the assistance of colleagues and academics in the field of math and ecology education. Suitable modification might also be achieved by reading the works of professionals in different fields (e.g.,Haggett, 1975; Peters, 1983; Thompson, 1966; Wratten, 1980; Vandermeer, 1981).

In the light of what has been said, it is imprecise to claim that success in ecological field-work and experimentation lies in the students' understanding and ability to use mathematical skills which help students to go beyond getting a numerical answer to consider the significance of the answer with regard to environmental problems. And to do so, students should be able to calculate, to reason quantitatively, to clarify issues, and to support or refute opinions (Frankenstein, 1983) and decisions in regard to the environmental implications of events at the local, national, and global level.

To conclude this discussion, there seems to be a need for including more applied math and using it as for the examination of real biological and ecological phenomena and relationships. The need, however, is not to replace ordinary language with math language, but to create a balance between both (indeed between all visual, verbal and mathematical models) in order to foster students' understanding of ecological concepts and principles. Here, a more integrated approach to quantification within the learning process, rather than a dominance of numbers, is needed. This call, however, extends beyond the biology teachers to include professional educators. More research should be conducted on the integration of school math in teaching ecology. Also, there is a need in research to locate the problem, whether in teachers and teacher education, school curricula, the educational system in general, in society, or in something else.

Human Ecology

Human ecology is the study of human beings in relation to their environment and, as such, encompases the full range of human activities, biological, social, and cultural which collectively account for the way that human species live. It is thus the study of the relationship between the total environment and the human community as a whole, including the impact on environmental quality. It must incorporate an understanding of the deeper structures of tradition and human beliefs and how these influence the relationship of humans with their environment. Human ecology then requires an integration of scientific, social, political, economic and ethical domains.

According to Brett-Crowther (1985) Human ecology deals with two facets :

> First, there is the observation of the many environmental problems, caused by human problems and also those caused by natural processes, all producing human impact. This is conventional science: the scientist seeks to find out what is happening. Second, there is the reflection on these data, their interpretation and the processes of action which may follow. It is reasonable to distinguish other elements in the multidisciplinary subject. .There are the social and political...as well as the philosophical and ethical. That realm includes questions of value as well as fact. For example, what is happening to the family under the impact of an employment _ or an unemployment _ pattern ? What is a man's identity or a woman's identity in the present age? What are rights and duties in the context of the population problem ? How much of what culture has given us as true notions of conduct and self-image remains true? (p. 195 -196)

Human ecology can help us to understand ourselves, our cultural relationship with nature, and how individuals and societies engineer and monitor their resource exploitation to maintain a dynamic equilibrium between the population and its resources. It helps us to understand and alleviate the problems we now have and may have in the future with regard to our natural support system and the existence and survival of humankind which depends on it. To ignore human ecology, is to invite ecological as well as cultural disaster in present human history (Sponesel, 1987). Having acknowledged the overwhelming importance of human ecology, we must now look at what secondary school students should be taught under human ecology?

What should we teach our students under human ecology?

I propose that teachers might start with issues such as: human nature, man's place in the natural world, human values and institutions, and/or sustainability and sustainable society. Because human ecology includes more than the understanding of just these four themes, this is not to be considered an exhaustive list. But, whatever teachers select to teach under human ecology, it should be represented to the students in the context of the relationship between human culture and natural ecosystems.

Human nature

The study of human nature seems important because history and human cultural revolutions testify that the ecological maladaptive behavior of mankind has increased with every cultural transition. A realization such as this seems to be what promoted Swan (1974) to argue that "an environmental educator must have not only a basic understanding of the environment, but also a basic understanding of man. Any theory of environmental education, therefore, must rise from the fusion of these two bodies of knowledge" (Cited in D.W. Rejesk, 1982, p. 27). Without an understanding of our human nature it seems fruitless to question our present lifestyle and cultural behaviour, even though that behaviour threatens the capacity of the earth to support, not only our survival, but also the existence of our species. In other words, without a better understanding of our nature, it seems hard to understand that it is in our interest to safeguard ecosystems and living species. Rachel Carson (1962) wrote "I truly believe that we in this generation must come to terms with nature, and I think we are challenged as mankind has never been challenged before, to prove our maturity and mastery, not of nature but of ourselves" (Cited in Ehrlich & Ehrlich, 1970). While Lynton K. Caldwell wrote:

> The environmental crisis is an outward manifestation of a crisis of mind and spirit. There could be no greater misconception of its meaning than to believe it to be concerned only with endangered wildlife, human-made ugliness, and

> pollution. These are part of it, but more importantly, the crisis is concerned with the kind of creatures we are and what we must become in order to survive.[1] (Cited in Staniforth, 1987)

In other words, it is also concerned with being and becoming.

Humanity and values

In present human society, the immediate usefulness of things to life and the lifestyle of human beings are what determine the value and quality of a given thing. A value approach such as this ignores for example the instrumental and the intrinsic value of many other species not only in maintaining our life support systems, but also in their own survival, both within the web of life. For example, a dead crocodile at the bottom of a deep river in Africa or Australia does not have any instrumental value in the mind of a crocodile hunter, but for many river creatures it might be a source of food, shelter, etc. By the same token, a fallen tree in any forest, can be a source of food and/or shelter to many different living organisms, something without which our natural life support systems would fail. But this same fallen tree might be useless and without any instrumental and intrinsic value in the mind of a logger unless he can sell it to a market. What might not be considered is that when the parts of this fallen tree disintegrate in the forest floor, it becomes part of the cycle which makes life on earth possible. As Costanza and Daly, (1987) argue, "Some notion of intrinsic value must therefore be introduced as a check on human perceptions and to allow us to study the economies of nature which do not include humans" (p. 4).

Conflict is another dimension of human nature that teachers might consider in teaching human ecology. The conflict between the perpetual laws of nature and people's wants is an important one. This conflict can lead people to make decisions with undesirable consequences for both humankind and the capacity of the earth to support human life and

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1- In order to survive we must make a major transition of our consciousness. According to Karan Singh (1987) formerly Head of State Jammu & Kashmir, and Union Minister of Health & Family Planning, India :" We must make the transition to complementarity in place of competition, convergence in place of conflict, and holism in place of hedonism. We must, in short, move rapidly into a new, global consciousness to replace the present fractured and fragmented consciousness of our human species." (p. 3) therefore for humankind itself. One of the reasons for the increase of ecological destruction today is this present conflict between economy and ecology. For example, maintaining the earth's carrying capacity in supporting human survival and life support systems, demands not only population control, but also consumption and distribution control, as well as peaceful coexistence among human beings and between mankind and other living organisms. If we believe that conflict is necessary in order to bring about change, then perhaps something of the mechanics of the nature of change should be included in the study of ecology in order to understand the complexity of the ecological crisis as it relates to humankind and his/her economically based society. Rescuing the earth's carrying capacity in supporting human survival and life support systems, is not only economically possible (Pearce, 1987) but also essential for achieving and maintaining sustainability.

Sustainability and the sustainable society

Reaching a sustainable society has been one of the goals of almost all environmental organizations. In recent years however, the question of sustainability and how it should be achieved has gained prominence in scientific literature. According to Brown, et. al, (1987), many believe that a sustainable society is represented by zero population and zero economic growth. Requirements for such sustainablilty are harvest regulation, renewable resources, soil and water conservation, and less affluent life-styles (Milbrath, 1984), as well as a philosophy of "empathy, compassion, and a sense of justice for all" (Brown,et. al , 1987, p. 716). Others believe that there cannot be a sustainable society because economic growth is inevitable with population growth, and the the acquisitive nature of people leads to technological innovation and increased demand. Even though aggression and competition have been percieved by many as the dominant forces in the nonsustainable society, the zero economic growth"would lead to unemployment, greater inequality, and a threat to peace" (Thurow, 1980; cited in Brown , et al., 1987, p. 716).

Yet, two points can be seen in recent related publications regarding sustainability. First, and as Brown, et al. (1987) have pointed out, most of the definitions of sustainability either "state or imply that the goal of sustainability is human survival and do not accept the desirability of a sustainable biosphere without the existence of Homo sapiens" (p. 718). Second, most of this literature either ignores or fails to see the merit of the educational role in achieving a sustainable society. It is here that human ecology can play a major role in delivering the message to the future generation.

The concept of a sustainable society that our students should understand is one that is ecologically sound, environmentally attainable, economically possible, and educationally achievable. A sustainable society is one in which humans can survive without jeopardizing their own continued survival as well as that of other living organisms and the future generations of all life forms in a healthy ecosystem. In human terms, a healthy ecosystem provides the opportunity for all humans to enjoy a quality of life "beyond mere biological survival"[1] and without threatening the capacity of the earth to support human life. This worthwhile goal requires, however, the maintenance of all components of the ecosystems and in turn the biosphere. It has been widely understood that the protection and conservation of genetic resources and of biological diversity regardless of the individual's or species' value to humanity, is an important element toward achieving a more sustainable society. A challenge such as this demands not only the integration of ecology conservation, economic development, political decision, and educational philosophy and goals, but also peaceful coexistence both within and between all life forms including human beings in present and future generations. Yet, as Ayers (1972) argues, until we accept the premise that "the survival of the human race depends on ecologically sound environmental management, and that every single one of us must reevaluate our habits and attitudes, we

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1- For our species " mere biological survival" is meaningless. This is because the implication of "no value" precludes for our species any sustainable future.

are wasting our time talking" (p.3)[1] Building a sustainable society is not only possible, but also a necessary condition for human survival (Brown, 1981).

Evolution

Evolution is the branch of science that deals with the complex mechanisms that make up biological evolutionary change. Every living organism, whether micro- or macro- and whether human, plant, or animal, is shaped by its physical, biological and social environment. Every organism conforms to its environment because it is constantly being molded by this ever-changing ecosystem. Its very existence depends on its ability to adapt. The key to survival however, "is not resistance to change, but meeting change with change" (Wagner, 1974, p.5). Maxwell, et. al, (1985) argue, "the concept of continually changing species, each constantly acted upon and thus modified by its environment, is a cornerstone in the construction of ecological theory" (p. 15). Indeed, today many scientists argue that nothing in biology makes sense except in the light of evolution (Dobzansky, 1973). It would be hard, for example, to understand the behavior of many living organisms (especially human beings), without an understanding of population and evolution.

Evolution is one of the few subjects that makes science and ecology socially relevant and important. The study of evolution enables us to understand that all living things originated from a few primitive life forms, and that therefore, many of the biological conditions of human life are shared with all other creatures. Evolution leads to understanding the relationship between human civilization and natural systems. From the study of evolution we understand that each individual organism exists as part of a particular population, species, community, and ecosystem (Savage, 1977). Furthermore,

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1- Human ecology is one of the ecological topics in which biology and ecology teachers can use the experience and the knowledge of teachers from other disciplines, because as Kormondy (1984) argues a topic such as human ecology might be too diverse and wide ranging to be taught by any one person.

understanding the main principles and concepts of evolution makes it easier for students to understand the basic concepts which are so important to grasp if we want to understand nature as it really is. for example, that the genetic code is universal for terrestrial life forms, that basic mechanisms of life are very similar in seemingly diverse life forms, that we are part of an interrelated web of energy and life on the planet earth, and that diversity and unity are characteristic of living systems, etc.

Because of its central importance to the understanding of biological and ecological phenomena, evolution today occupies a unifying position within the field of biology and ecology in higher education. It has also been widely suggested that the concepts of evolution be used to integrate topics both in high school biology textbooks and in classroom teaching. Davies (1985) argues that evolution "would provide a better opportunity for teachers to provide materials to stimulate the thinking of pupils.... Once the thinking of pupils has been stimulated, discussion groups would be easier to investigate and practical sessions made more open ended and less of a recipe--following type" (p. 258). However, despite the importance of the concept of evolution to understanding today's biological and ecological concepts and principles, North American high school students are learning less about evolution today than ever before (Skoog, 1969; 1979, 1984, Cho and Kahel, 1984).[1]

It is my contention, based on the information and facts presented in this thesis that one might see a definite relationship between the acceleration of ecological crises, the dominant anthropocentric viewpoint in high school biology textbooks, and the lack of an adequate emphasis on evolution in high school biology education. Most anti-evolutionists believe that humankind is the center of moral concern and the rightful authority over all non-human life as well as over the natural world. This attitude is one of the basic features

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[1]- Skoog (1984) concludes " there has been definite erosion in the coverage of evolution in all high school biology textbooks " (p. 126) published since the 1960's and up to 1983. Many high school students today have a great deal of knowledge and information about evolution but only from out of school sources which are based generally on anthropomorphic attitudes.

of both speciesism and resourcism. I would be happy to see those who are against the inclusion of evolution in school curricula devoting some of their energy and time to fighting those who are destroying the environment and world ecology.

I understand that the inclusion of topics like evolution in ecology curriculum might make a few teachers, parents, and even a few scientists and politicians uncomfortable. But the emphasis in ecological education must be on ecological and evolutionary topics such as mutualistic interactions, etc. Furthermore, as Davies (1985) argues,

> Contemporary scientific debates about evolution are not about whether evolution has occurred but rather about whether the mechanism proposed, that is adaptation natural selection, is a sufficient cause for change. It is hardly a sound reason to omit evolution from a syllabus because there is disagreement over the mechanism of how it has taken place. Other biological topics, such as photosynthesis, for example, are still incompletely understood. (p, 258).

This of course doesn't stop photosynthesis from being an important subject in biology education. Furthermore, as Mayr (1982) argues, it is perhaps fair to state at the outset that, "no well informed biologist doubts evolution any longer. It is probably equally fair to say that the vast majority of well informed lay people accept evolution as readily as the fact that the earth circles the sun and not the reverse" (p. 626).

In summary, the importance of evolutionary ideas in teaching ecology at the secondary level is based on the following facts: (1) In terms of individual living things, evolution includes the processes of producing new life forms from old, and generating and maintaining diversity; (2) In terms of the whole biosphere, it is the processes of increasing the complexity of the biosphere, which enables it to "include even more of the material of the earth into ongoing cycles" (Feinberg, 1985, p. 62). Furthermore, Bradshaw (1984) gives three major reasons why evolution is a proper subject for ecology and ecologists:

> (i) We all tactically assume that what we examine ecologically is the product of evolution, and that as a result of natural selection it is adapted, more or less, to its environment, in the sense that it is fitted (*aptare*) to (*ad*) it.
> (ii) Species are clearly not fixed, but consist of a complex of different populations, often with extremely different ecological properties, which can change as a result of evolutionary processes in only a few generations.

(iii)Ecologists themselves study life and death, and mechanisms of fitness which are the stuff of evolution as we understand it. (p.1)

He adds, "...not only does evolutionary thinking form a conceptual background to ecology, but there is a two - way relationship between ecology and evolution, in that the findings of each is very relevant to the other"(p.1).

Eco-Ethics

Eco-ethics is concerned with the relation between ecological concepts and human values and attitudes and is aimed at developing in school children an attitude of responsibility toward each other, other living species, and the natural world. In general, ethics deals with the normative questions of what it is proper for us to do in our daily lives which must involve choice and decision. To behave ethically, according to Kieffer (1979), is to "...ask and try to answer questions regarding what action is right; or in ethical terms, is the ought behavior" (p. 177). Such questions involve difficult value judgments and decisions about the environment, comprising "a complex mix of political, economic, scientific and philosophical arguments" (Van Hulst, 1986, p. 117). This may explain why:

> ...many instructors shy away from topics that are value-laden; or if they do introduce them (usually as an optional part of a unit or course), they leave students to work out the issues on their own with little or no guidance. Often such an approach leaves students bewildered and frustrated. A more serious result is the complete rejection of science by some students, which, in their view, has created serious hazards for society. (Kieffer, 1979, p. 177)

Nevertheless, there are many reasons to include the teaching of ecoethics in secondary school science curriculum. According to Kieffer (1979):

> Normative ethics deals with developing a set of principles that guide us in judging which acts are right or wrong, good or bad, obligatory, permissible, or forbidden. Ideally, normative ethics embodies some core of values that serve as the foundation for important value decisions. They function as guides for directing correct or ought behavior. To have a normative ethics is to be prepared to do something; and the more developed the normative ethics, the more forceful and systematic will be the course of action. (p. 177-178)

According to Morse (1986), when speaking of environment and ecology education, environmental ethics,

> ... provides both principles to follow and ends to be achieved in any role that may be imagined for man. It offers a basis for the development of a higher individual and public morality in such diverse matters as the exercise of responsibility, the size and distribution of the world's population, the nature of human settlements, the design and quality of artifacts, workmanship, the management of natural resources, the maintenance of the full spectrum of plants and animals, the handling of pollutants and the allocation of social costs where they arise from private use of the environment. (p. 19)

Yet the fact remains that even now, with ecological crises and environmental problems continuing to escalate at an alarming rate, the importance of ecological and environmental ethics has not become an essential factor in shaping our present educational programs (Brennan,1986). In school education, eco-ethics tends to be forgotten for a variety of reasons. One of these reasons might be the widespread, although mistaken, belief that science "is based on objectivity, and value judgments are foreign to its precise, logical methodology" (McCormack, 1983).[1] Nevertheless, it is important to recall Moore's claim (1971) that an "educational program in ecology aimed at any level of the public will have to incorporate moral, aesthetic, and ethical principles in the presentation of the scientific concepts of ecology" (p. 57). McCormack (1983) agrees: "development of skills and courage to make well-considered, logical, non-self-centered decisions should be given highest priority in all our school science programs"(p.). Now, however, the question is not why teach eco-ethics, but what should we teach in eco-ethics and how?

<u>What should be taught in ecoethics</u>

Ethics in general deals with how we make or ought to make choices and decisions on the basis of the proportionate good and right. Thus, the learning of principles that help

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[1].Ethical questions and value judgments are not part of the methodology of scientific training of many scientists (McCormack, 1983; Kieffer, 1979). As a consequence, scientists and science teachers McCormack (1983) argues, have traditionally remained aloof from the impact of science and technology on life on this planet and they see value issues as outside their domain.

us to determine which ecological acts are good or bad, right or wrong should provide the basis for eco-ethics in secondary schools. The skills and techniques of critical thinking necessary for value judgment and decision making are also important. Anything, therefore, should be involved that can enhance the understanding, use, and achievement of guidelines or skills necessary for ecological choices and decisions should be included. According to Morse (1986), the development of environmental ethics, should involve at least the following:

> A) the development of a conception of man himself; B) the acceptance of certain principles respecting the relation of man to man; and C) the development of an approach by which to judge the acceptability of environmental use, the relation of man to nature. (p. 24)

Morse's view implies that something is currently wrong not only between man and nature, but also between people themselves. If this is the case, the relationship between human beings and their compassion for each other should be one of the fundamental requirements for an ethically correct relationship between human beings, their society and nature itself. Dasmann (1976) states "We lack understanding of ourselves, of others, and the environment on which we depend" (p.2). Only by having a clear understanding of ourselves, Iltis (1966) argues, "can we change the understanding of others, understanding that will eventually result in intelligent conservation, in responsible agriculture, and in a new land ethics, in short, in the new ecologically-oriented human society of the future" (p.19).

Yet, teachers have to be careful not to impose their own or any particular set of values on students. Instead, as Bybee (1979c) argues, we should teach them to be critical about values by presenting them with the critical choices and options. Livingstone (1981) and Van Hulst (1986) claim that we have a moral duty not to foreclose options on behalf of future generations, but to maximize present and future choices for those generations. We should let them know and understand that our values are not to be imposed on them (nor perhaps on any other living organisms even though humans can interfere for the good of the environment). Hurd (1986) also reminds us that, "teaching students a particular set of values is not the objective. Rather, the aim of teaching value-laden science is to provide students with opportunities to integrate valid science information into the making of ethical judgments" (p. 354-355), and to distinguish between different kinds of given choices. DeDecker (1987) also agrees when he says that "...we must provide a process through which students, and thus society, may begin to identify values and examine the problems likely to be faced" (p. 428). Accordingly, while it is important to teach students to be well informed about themselves, their relationships with other people, non-human organisms, and nature, we should also give them some useful criteria by which to examine given values; show them how to apply a useful set of criteria in value selection processes and how to make a choice and decision that is morally and ethically acceptable by a person as an individual, a member of a society, and a component of a highly diverse and complex ecosystem. Therefore, teachers can start teaching ecoethics by developing an understanding of relationships among humans, human treatment of non-human organisms, and our relationship with nature. The understanding of oneself, however, is a crucial element in understanding these principles of ecoethics. The following diagram shows the relationship of these principles to each other.

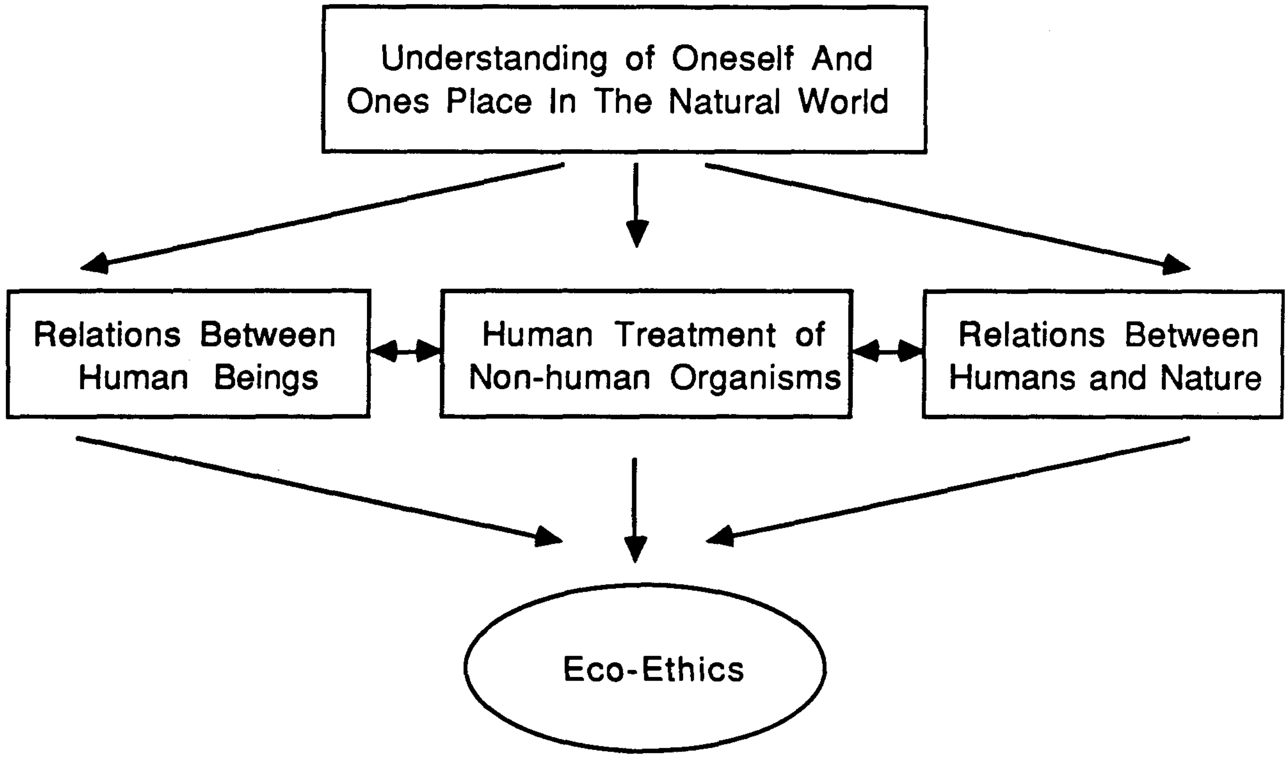

Figure 7.1 shows the relationship between developing eco-ethics and the understanding of the relationships among humans, human treatment of non-human organisms, and human relationshipswith nature

Aims of these categories

The aim of understanding oneself and ones place in the natural world is to develop a clear conception that the very existence of living organisms, including humans on this planet, depends "on the fundamental soundness and integrity of the biological system of nature" (Charles, 1986, p. 44). It is also to understand and maintain sense of responsibility for the consequences of our actions. It is, moreover, biological and cultural understanding of oneself that helps one realize that one is a member of the life community on our planet. The first stage in this model of ecology, amply understanding oneself and the human place in the natural world, has I hope been demonstrated at this point.

The aim of understanding the relationships between human beings is to develop the attitudes of an equal person among equal humans. The aim of understanding human treatment of non-human organisms is to develop an awareness and understanding that life in its totality is a complex and unified web of interdependent parts, yet, each has its own unique ways of participating and maintaining life function and life support systems.

The aim of understanding the relation between humans and nature is to expose the fallacies of the indestructibility of nature as well as to understand that mankind is an inseparable part of the nature that produced him through both biological and cultural evolution. This means that mankind "needs nature as part of his very existence, because this need is part of his adaptational inheritance, the result of his long biological evolution" (Iltis, 1966, p.21). In other words, the aim of understanding the relation between mankind and nature is to develop the attitudes and behaviors appropriate to the adequate use of the environment and natural resources. It is the wise use of natural resources that maintains an adequate balance between the population of living species and resources.

Relations among human beings

The rationale for including an understanding of the relations between humans within ecoethics is that it is unlikely that people will understand, accept, and look compassionately at non-human species if they are unable to appreciate the rights of certain members of their own species. It is my argument that it is unlikely that people would accept, for example, that a fallen tree in a rain forest has value independently of human beings if they fail to respect other people even within their own cultural, historical, and geographical framework. It is understandable, however, that the complete acceptance of one's fellow humans requires certain social and environmental circumstances such as peace and justice within human communities together with cooperation and friendships between populations so that there is stability in social, economic and environmental matters. Such cooperative interaction among people as well as between people and nature would itself go a long way toward enhancing the integrity and stability of the global ecosystem.

As in most other societies, many of us in the west are taught to make contact with other people and with the natural environment, but we are not taught to welcome learning something from the exchange (Turnbull, 1984) or even that there might be a practical benefit from discovering the culture of other nations. Rather, we are taught that western ways and lifestyles are best for the rest of the world and that the only worthwhile species is our species (Sauer, 1956). We are taught to impose our values on other human beings and on the animal world, and are blinded to the value systems of others. Maybe when we start to respect and protect the rights and freedom of other people, regardless of our differences in culture, religion, ideology, race, color, geographical location, or economic status, we can consider the importance and value of nature and its non-human organisms and non-living components as being part of one life for all of us; one interrelated world society. Although we are different by nature, this should not be a reason for dispute between us, but rather a reason for mutual acquaintance and cooperation. If we could learn to get along with other people in our own family or neighborhood, society, or world, we probably develop the right conscience to respect the rights of animal and plant species as long as they don't upset the natural stability of the global ecosystem. If so, then peace between the members of the human community might be the key for achieving an ecologically harmonious society. Perhaps then we can accept for example, that, when a given organism does not frighten human life or the stability and homeostasis of ecosystems, it has a natural given right to follow its own intertwined evolutionary destiny without being a meaningless creature in environment managed by human anthropocentric perspective (Sale, 1986). It is probably only with world peace (between individuals, communities, and societies) that any ecological balance can ever hope to be achieved. World peace and ecological harmony, many believe, are inseparable. Of course, this is not an easy job because it requires changing human society from anthropocentric into ecocentric which nothing less than: 1) "a reinvention of the human at the species level" and 2) "...a total reorientation of the thrust of Western culture" as Thomas Berry and George Sessions respectively put it (Cited in Sale, 1986, p. 28). This cannot happen without transitional phases and commitment for peace, freedom, and rights within members and between human communities in the world.

Human relations to non-human organisms and the natural world

Every living organism whether human or fellow creature, has both intrinsic and instrumental value. In other words, every living creature is both ends and means in a highly diversified, integrated, complex ecosystem. A convincing argument for a claim such as this can be found in Brich' and Cobb's (1981) remarkable book *THE LIBERATION OF LIFE* and particularly in chapter five "An Ethics of Life". They argue that:

> Ethics has not been wrong to emphasize that human beings should be treated as ends. The error has been to pretend to ignore that human beings are after all means to one another's ends and try to make absolute the distinction of ends and means. It is proper for human beings to serve as means not only to the welfare of other human beings but also to the welfare of other creatures. This is not sheer sentimentality. It is a duty. (p. 162)

They also add that, "Ethics, laws and economics should take account not only of the uses of animals [instrumental value], but also of their rights, which are correlative with their potential for richness of experience [intrinsic value]" (p. 154).

Human individuals might not be able to realize animals' capacities for the richness of experience as they might do with the other human individuals. If they could, Brich and Cobb (1981) claim humans at least will be able to reduce the amount of pain and suffering they inflict upon other creatures. However, while many of us today have been convinced that animals have rights "which are being pervasively violated by human beings", we have not been convinced that "among these rights is the absolute right to life" (p.155).

Our way of life should be based on the rights of the individual, community, society, and the world. There are moral obligations and biological reasons for every creature's right to survive and all species to proliferate as long as they do not upset the diversity, integrity, and complexity which are necessary for the stability of the ecosystem. Equally, there are rational as well as biological reasons for the natural laws of nature and life such as natural material cycling and energy flows to be maintained for the sake of the homeostasis of ecosystems.

No individual wants to live in a polluted environment, breathe polluted air, drink polluted water, or eat chemically saturated food. Every tree, as an integral organism in the ecosphere of this planet , flourishes best under clean rain as opposed to acid or nuclear rain. Every bird flourishes better when it flies in air unpolluted by nuclear waste, smog, and chemical fog and dust. Session (1983) argues that, "All of nature has equal intrinsic value and the right to blossom into its own particular form of realization" (p. 34). Every organism specializes in a different way, and does a different job in the overall flow of energy. The destruction of the natural way of living of one organism or one species will substantially affect the survival of the other creatures, and simultaneously the entire ecological system. Yet, anything which can upset the integrity, stability, and homeostasis of ecosystems should be controlled. Here, human beings need to be able to distinguish logically between different kinds of questions and different kinds of choices in order to make the right decisions regarding the natural right and freedom of every organism (including other people) to flourish under the best natural conditions. They need to develop rational understanding, critical thinking and rational action.

For example, the overexploitation of rain forests by multinational corporations, a fact which is overwhelming in many of Latin American countries, denies the freedom and rights not only to over 50 % of all living species on the earth living in the rain forest, but also other living organisms all over the world, including human beings. Rain forests are not only the most diverse and complex ecosystem on earth, they provide us with food, medicine, and new types of energy sources, and also work as one of the world's greatest climate cooling systems. A rain forest which is located on the equator is constantly circulating water between the earth and atmosphere and thus affects the climate of both the Northern and Southern hemispheres. It makes its own climate; it is a tremendous water circulating machine, it has a perfect evaporating circulating transpiration system. About

75% of the water that comes down on the forest is put back into the atmosphere in the form of evaporative transpiration and that acts as an immense cooling machine for the atmosphere of the planet. Perhaps soon we will have serious changes and dislocations in world climate, and that will certainly affect the temperate regions, such as all of North America, North Europe, Siberia, South American, parts of Asia, and Africa. Scientists already worry that the current mass destruction of the tropical forest might have something to do with recent drought and famine in some countries such as in Ethiopia and Sudan. Moreover, there is a more immediate and direct problem as the result of the overexploitation of the tropical forests. Everyday at least one of the rain forest species becomes extinct, and by 1990s, the lose will be one species an hour; the highest extinction rate since the origin of aerobic life (e.g., Ehrlich, 1986; Simberloff, 1986; Slobodkin, 1988). The most noticeable loss will be the large mammals. Thus, it is in the interest of all human beings and all other living creatures that inhabit, not only these forests but all kinds of ecosystems, to preserve as much of these forests as possible. This cannot be achieved without the realization of the rights of all living creatures to flourish under their natural conditions.

It is my belief, therefore, that in order for human beings to fit into ecoethics as cogs in the harmonious wheel of life, they cannot dominate any other organism, or manage and manipulate the energy flows and material cycles solely for their own benefit and use if such domination will affect the homeostasis of diversity and complexity of ecosystems. Generally, we all enjoy comfort, a supply of food and energy, the convenience of automobiles, and the security of a job. But this does not mean that it is acceptable for humans to pollute the air, water, and land; to destroy forests, and the non-renewable resources of the environment; to cause birth defects by chemical pollution or to kill plants, animals, and human life through industrial pollution. The storage of nuclear waste materials, for example, limits the rights of natural survival of all life for millions of years because it takes so long to lose its radioactivity. If we store plutonium, we may "...have to worry that, say in ten thousand years, no one will be able to read the signs posted because languages will have changed" (Calypso Log, Sept., 1985, p.4). It is an immense presumption for humankind to believe that Homo sapiens is superior and therefore justified in controlling directly or indirectly all other life forms on earth.

Environmental Behaviour

Environmental behavior is the action component of ecology education. It aims at developing ecologically responsible and active citizens through the development of investigation skills and action techniques (Monroe, 1987; Volk, 1987; Ramsey, et al., 1981; Klingler, 1980). This goal has not yet been achieved even with the various calls for action in literature concerning environmental issues. One of the reasons for this failure is that most existing ecology and environmental programs remain heavily weighted toward ecological knowledge and awareness of environmental issues (Elkin, 1977) without an education dealing with the implementation of the right curricula and instructional strategies (Hines, Hungerford, and Tomera, 1984), or a plan for action. Indeed, while environmental education implies action, McClaren (1987) points out to the fact that "...public schools are extremely wary of action" (p. 55). This concern has rendered the concerned citizens helpless, and made their experience irrelevant. Elkin (1977) argues that thinking of the environment only in terms of pollution, losing productive farmlands, depletion of non-renewable resources, etc. will produce overwhelming feelings of helplessness and insignificance among many people. He states:

> The problem of managing the environment appears to be beyond our control. The warnings of ecological apocalypse do not spur us to action, but leave us cynical and despairing, perhaps wishing that there was something we could do, but not knowing what nor how. (p.273)

To solve the problem Elkin (1977) suggests:

> The key to environmental education, indeed all education, is in enabling individuals to learn why and how to act effectively on their environment and to select and manage the quality of their own experience; to enable them to determine for themselves what is "worth doing" and to develop a general understanding of the nature of doing, or actions, so that they will be able to carry out their intentions. (p.274)

This simply means people should think and use reason in their actions.

Developing ecologically responsible action among individuals demands first of all that teachers provide the conditions necessary for creating the desire in students to act effectively, the ability to act effectively, and the confidence and comfortable inner feelings to act effectively. These three conditions are necessary in the development of personal competence to produce ecologically responsible action. This, of course, requires that teachers themselves should be "...environmentally sensitive and knowledgeable, skilled in responsible decision - making, and active in environmental maintenance and remediation" (Volk, 1987, p. 118). I would not underestimate the feeling of helplessness among concerned citizens, both the barely informed and the well educated, who want to act, and see the world eco-crises as so overwhelming that they turn their efforts elsewhere. I believe that a silent army of this type of person exists who, with the right educational program, could find hope and the method in which they could make a difference. It is true that there is a multitude of people out there who are truly unaware of the seriousness of ecocrises, but I feel there are just as many who are aware enough to know something must be done, but just do not know what that something is. That is why I agree with McClaren (1987) who argues that "...there are things to be learned through action that can simply not be learned in any other way." He adds there is "...a kind of information that becomes available in the course of an action that does not exit without the action" (p. 55).

The prediction of behaviour is an extremely complex process because it is based on a multitude of factors. Of the various environmental action models available in environmental literature, Hines, Hungerford, and Tomera's (1986) environmental behavior model seems the most suitable for the ecology core curriculum this thesis proposes. Hines, et al (1984) developed an Environmental Behaviour Model (EBM) based on the results of the meta-analyses of environmental behaviour research conducted over the past decade. They believe that this model (EBM) has the factors which are most strongly associated with responsible environmental behaviour. These factors or components are : 1) Cognitive knowledge of environmental issues; 2) Cognitive knowledge of action skills and action strategies; and, 3) Personality factors. Hines, et. al (1986) believe that these factors can bring intentions to act and, in turn, responsible environmental behaviour. Therefore, they recommed that the three factors that provide individuals with opportunities to develop and to practice those skills and actions strategies necessary to lead to environmental action be developed and implemented in American school systems.

The model is based on the assumption that people who have the attention to take action are more likely to engage in the action than those who show no expression to do so. However, an intention to act "is merely an artifact of a number of other variables acting in combination (e.g., cognitive knowledge, cognitive skills, and personality factors)", (Hines' et. al, 1986, p.6), and thus a prerequisite must be met before individuals can intentionally act on a particular environmental problem. An individual according to Hines' et. al (1986) must:

1). Be cognizant of the knowledge of the problem of the existence of that problem.

2). Possess knowledge of the courses of action available which will be most effective in any given situation (Hines et. al, 1986, p 6).

3). Possess a desire to act which most likely is affected by a host of personality factors such as locus of control, attitude, and personal responsibility. Yet, the action requires an ability to act.[1]

4). Learn the skills that enable him or her to covert and appropriately apply the knowledge into action strategies in a given problem.

5).Situational factors (e.g., economic constraints, social pressures and opportunities to choose different actions) which may counteract or strengthen the variables in the model,

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1- According to Hines' et. al., (1986), "an individual with an internal locus of control, positive attitudes toward the environment and toward taking action, and with a sense of obligation toward the environment will likely develop a desire to take action" (p., 7). Yet, the action requires an ability to act.

must also be manipulated if the desired behavior change is to be produced (Hines, et. al,(1986).

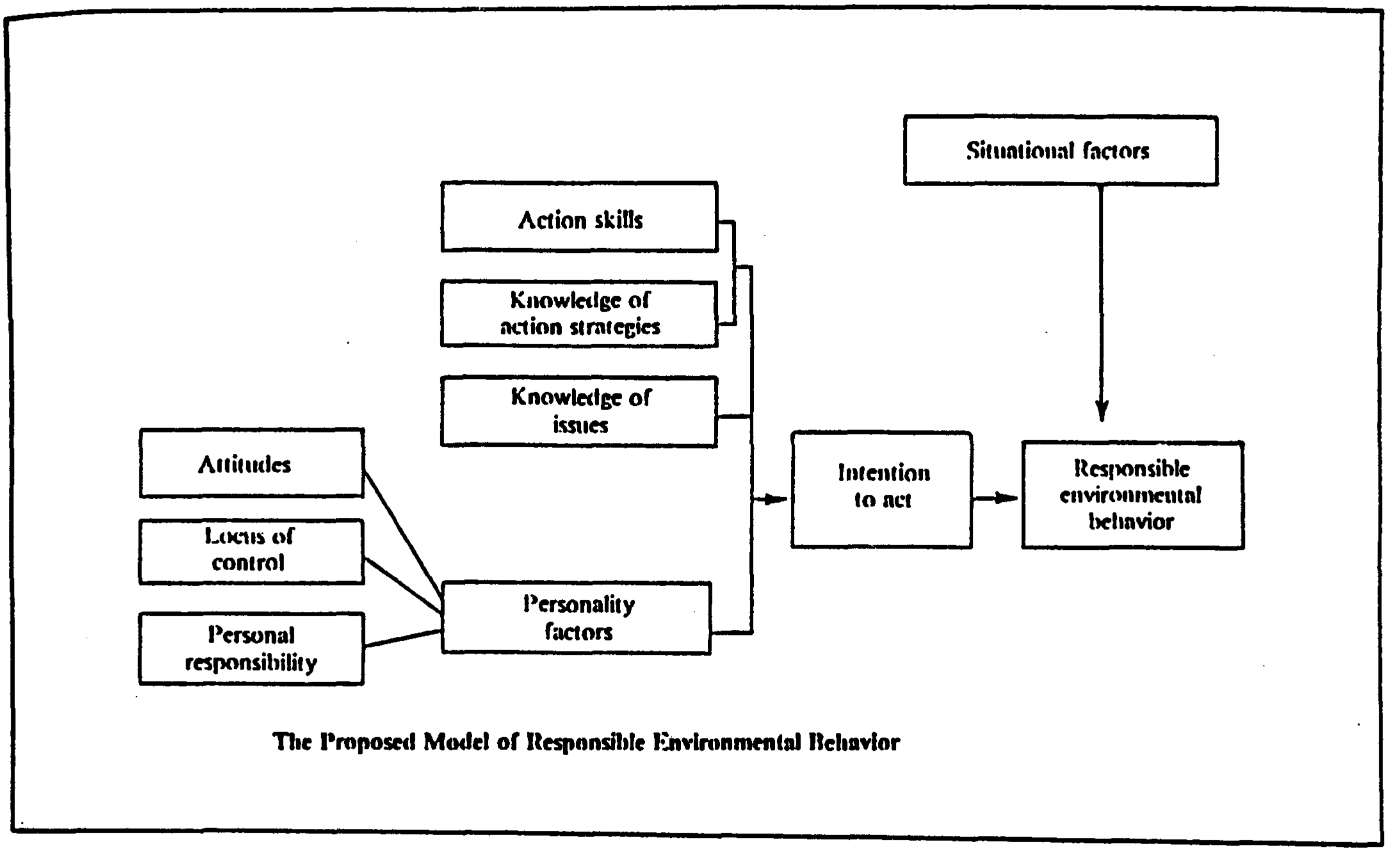

Figure 7.2 The model of responsible environmental behaviour proposed by Hines, Hungerford, and Tomera (1986) based upon the results of the meta-analyses of environmental behaviour research conducted over the past decade. This model can be a good starting point for those teachers who want to teach ecologically-oriented programs because it includes all the factors which are most strongly associated with responsible environmental behaviour.such as: 1) cognitive knowledge of environmental issues, 2) cognitive knowledge of action skills and action strategies, and 3) personality factors.

Urban Ecology

Urban ecology is one area of ecology which has captured the attention of a growing number of ecologists, environmentalists, and educators. It is concerned with the biological, physical, and social interrelationships between plants, animals, and humans in a city environment. Its purpose is to promote an awareness of the ecological systems and processes which they affect and are affected by (Dawe & Kunz, 1986; Hale, 1987). In short, it deals with the question of how ecosystems maintain their structure and patterns of behavior in the face of disturbance in the urban environment. In this sense, urban ecology does not aim to control systems or reduce their variability, but to understand them in order to bring them into a state of interdependence.

In order to better understand the environment in which we live it is important to understand the urban ecology. For instance, most of the vegetation in a city is mainly decorative or put up as a noise or dust barrier. However, these plants provide an environment for a surprising number of species such as birds, squirrels, and insects. The other city animals (such as rats and mice) and insects (mostly cockroaches, ants, etc.) and pigeons seem to reap their livelihood only from the concrete and human offerings and refuse. In other words, city plants and animals must depend entirely on the man-made environment for their livelihood, while plants and animals living in a natural environment depend on each other.

Like plants and animals, city humans have many sets of survival mechanisms they must employ. The dense population and complexity of the ecosystem ten to produce a competitive environment which promotes stress, anxiety, pressure, and even antagonistic behavior toward other humans that is not evident in a more natural environment. Even our relationship to animals is different in the city. Most of us value animals in cities as either pests or pets. In a more natural environment we have not only work animals and livestock, but a full array of wild animals living in a natural environment. There, we can see their place in the web of life perhaps more fully and appreciate their intrinsic value such as beauty, song, and their contribution to the maintenance of the ecosystem. Most of those animals would perish quickly in an urban ecosystem.

Why Should We Study Urban Ecology

The reasons for studying urban ecology are many, the most obvious being that the majority of people in the world are city dwellers for whom an understanding of the environment in which they live is critical. Thus, for more than half the world the study of urban ecology is vital in the study of ecology.

Studying urban ecology is also important in solving the problems of many city teachers who, finding no natural environment, neglect to teach ecology at all. The misconception that only a 'natural' environment is suitable for field work in teaching ecology has been replaced by the realization that the urban environment is more than adequate in interrelationships between natural systems, including humans. Study in this field has been done by Monica Hale (1985), who outlines eight advantages of studying ecology using the urban environment, all of which are good reasons in themselves for including urban ecology in the study of ecology. These reasons, briefly, are: 1) The obvious savings in costs on transportation, etc. 2) Savings in time. 3) The ability of teachers to be spontaneous or flexible in their research, experimentation, fieldwork, etc. without undue preparation. 4) The opportunity to carry out long-term experiments and monitoring of environmental factors and their effects (such as pollution). 5) The promotion of better structured concept-based studies, rather than the habitat type because of the additional time available to explore concepts in the local urban ecosystem. 6) The fact that children can relate to their 'own' ecosystem, and can develop a sense of belonging and caring for 'their' environment; one of the goals of studying ecology. In short, understanding the urban ecosystem leads to a better understanding and appreciation of natural ecological systems and processes.

What Should be Studied Under Urban Ecology?

A good place to start in the study of urban ecology is in the understanding of what an urban ecology is and what its main characteristics are. For instance, students should understand that an urban ecosystem requires an enormous input of energy provided mostly by humans, and that it generates an enormous output of waste that depends entirely on human technology to manage. This means that most city plants and animals depend on humans rather than on each other. Students also should understand that, when we live in cities we too are part of the urban ecosystem.

Students should be able to distinguish in detail between natural, changing and urban ecosystems. By calculating for example, the amount of energy, waste, and human effort necessary to maintain different environments such as these, students should be able to make decisions regarding the environment they might choose to live in.

Teachers should look at an urban ecology as an area of study in which students are able to apply and evaluate all their previous learning, ecological knowledge, and experiences. They might also view the urban environment as an area in which students would practise debating issues, making decisions, investigating and solving problems, etc.

What kind of Learning Activities Should Be Taught?

There are many activities teachers can teach under urban ecology especially when they consider their cities as a 'city ecosystem'[1]. One of these activities is called 'input and output of the city'. Teachers will first describe the typical city ecosystem. Then they will divide their students into two groups, one responsible for the city's input, the other for the city's output. The input group will gather information on input from sources such as the

1- cf., Hix, 1972; Ehrlich, Holm & Brown, 1976; Byerr,1979.

library, and then conduct a practical survey of input from the city itself. For example, they will ask the grocers where the milk comes from, where the bananas, juice, canned goods, etc., come from. They will ask the electric companies, the apparel stores, the gas stations, etc., where their products come from and list them. They will then analyze their information and information sources for clarity and validity and illustrate this input information in a drawing of their city. Data will then be interpreted and a written report will be prepared for future purposes.

The second group, the output group, will also gather information first from the library and then in the field (the city) and will likewise analyze their information and illustrate their findings in a drawing of their city. Written reports will be prepared for classroom discussion. Examples of output would be sewage, chemical air pollutants, toxic industrial wastes, garbage, goods manufactured in the city, etc. Since children in general like frequent fast-food places, students could start there in determining the use of packaging containers (renewable versus non-renewable), or service stations with respect to their disposal of used motor oil.

The two groups will then present and discuss their findings to each other in the classroom. At this time, "instruction must be provided on generating logical conclusions and inferences, and on making appropriate recommendation based on the data, rather than on emotion" (Volk,1987, p.121). The characteristics of the modern urban environment described at the beginning of the class will then be modified by their findings.

The next step is to compare the urban ecosystem to a rural environment and to a natural ecosystem. A mural of the city ecosystem could then be contracted as material for a debate between both groups, each supporting the input or output of the city. In this case, guest speakers might be invited from the city planning and development department to participate in the debate or to comment on it.

From activities such as these students learn many things such as (1) how to look for and gather information from both literature and the field, (2) how to classify, compare and analyze information and information sources for clarity, bias and validity, (3) how to interpret data and generate logical conclusions and inferences, (4) how to make appropriate recommendations and decisions, and most of all (6) how to become involved and practise involvement in situations that, as future voting citizens, they will have to face and make decisions about.

For homework assignment, teachers can use for example, *Water Use-Water Waste activity* (Cherif & Stanlforth, 1987) This activity can be carried out by students at home or at school. It is based on the following ideas:

1). While 75 % of the earth's surface is covered with water, fresh water is scarce in some parts of the world, and where water is adequate, pollution is increasing at an alarming rate. 2) There will never be any 'artificial' or synthetic water. 3). The flush toilet system in our homes, considered one of the critical problems of modern civilization, uses about 40% of all water piped into a home. The average person contaminates 13000 gallons of fresh water a year to wash away only 165 gallons of sewage.

First, get the students to measure the size and volume of their kitchen sink, bathroom sink, bathtub, and the toilet tank (water receptacles). Second, get the students to draw up a chart for a week-long period listing the four water receptacles, and providing an area to check each time each one is used. This chart can be just for the students, or for all members of the family. Students can keep track of how many times and how much water each individual (and then the whole family) uses with the four water receptacles (kitchen sink, bathroom sink, bathtub, and the toilet tank) per day and per week. Students can then relate the amount of water used to the activities surrounding water use, such as cooking, washing, brushing teeth, taking a bath or shower, or flushing the toilet.

Finally, ask the students to think of places that do not have an adequate supply of fresh water (a place where water is scarce and has to come from under the ground). Help them to choose a city or village in a desert or semidesert region. Ask them to imagine that they live there, however, they live in the same house and with the same lifestyle as they do here and use the same amount of water. Discuss the use of water; access to an adequate water supply; how the use or access affects our lifestyle; solutions to the shortage of water in desert and semidesert regions, and recycling water on both large (city or regional) and small (house or building) scales.

Urban ecology can be a very exciting subject for city kids who may not even realize they are part of an ecosystem. It is an opportunity to involve children in social and environmental issues and introduce them to the relevance of science and technology into their daily lives. Whatever teachers select to teach under ecology education, and whenever they would like to teach it during the school year, urban ecology should be taught at the end of the ecology curriculum. In this way, students can apply all their previous ecological knowledge and understanding to their urban and rural environment. They will evaluate, not only their previous ecological understanding, but also their ecological relationships in an urban environment and their own role and behavior within those systems.

Instructional Strategy For Ecology Education

Since what children learn is largely determined by what we teach and how we teach, the question now is what are the teaching methods or strategies that are most effective in teaching ecology? The following section deals with this question. However, as Pratt (1980) argues:

> The role of the curriculum designer is not to impose strategies on the teacher, but to help liberate the teacher from imprisonment within a limited range of conventional techniques; to suggest principles and possibilities that the teachers can apply creatively to generate new and more effective approaches. The structure and clarity of the scientist and the variety and imagination of the artist: these have been, and are likely to remain, the keys to instructional effectiveness. (p. 322)

How Should Ecology Be Taught At The Secondary School Level?

In order to propose an effective model for teaching ecology, we might first look at the basic principles of effective teaching. Many educators would agree that effective teaching takes place when the students learn to think critically, communicate effectively, and be able to develop self-understanding, self-discipline, and a commitment to life-long self education. In order to do this, teachers must use different teaching models and possess various tools and instructional materials, including books, newspapers, films, tapes, computer-mediated programs, etc. which promote student involvement in learning situation. As Jacobson & Bergman (1987) concluded, teachers who use a wide variety of teaching models have students who are always asking questions and testing ideas or hypotheses, which they see as "the essence of learning." For them, like many others (e.g., Pratt, 1980; Jocy & Wiel, 1983), variety is the essence of successful teaching. In environmental problem-solving for example, successful teachers used many teaching techniques significantly more often than did less successful ones (Monroe and Kaplan, 1988) based, not on familiarity, but on a review of the possibilities of those strategies that might have greater potential of achieving the learning objectives (Pratt, 1980). This means that teachers must use analytic thinking as well as the nature of the subject and learning objectives in the selection of their teaching approaches, and be organized in the preparation of their materials. Thus, effective teachers must master a range of models and use a combination of teaching strategies to increase their effectiveness in dealing with the specific kinds of learning problems they face (Joyce & Weil, 1983).

To answer the question, therefore, of what teaching strategies should be used to teach ecology at the secondary school level, I would say, since ecology is a subject with a variety of aspects to be taught to a variety of students, that it should be taught using as many methods (that aim at valuable understanding) as possible. The availability of various teaching models gives teachers the necessary tools for effective teaching in any given situation. This is not to deny that there are some very gifted teachers who possess the intuition and/or understanding of children to such a degree that they are able to devise their own teaching "models" without necessarily fitting them into a category of any particular philosophy of education. In fact, B. Othanel Smith, a pioneer in thinking skills and one of those who rejects the reduction of teaching to any sort of formula, goes so far as to reject teaching models "...because models give us formulas, and formulas squeeze the life out of teaching" (1987, p. 36-37). However, in order to reach the level of gifted teacher, I believe that most teachers must first experience or consciously learn and adapt the various teaching models.

Educators have identified many distinct teaching methods and learning resources that imply a particular range of instructional approaches (e.g., Joyce, 1987; Pratt, 1980). Joyce and Weil (1983) have recognized four ways, or distinct orientations toward people and how they learn. Consequently, they have categorized many ways of teaching, or teaching models into what they call, 'Four Families of Teaching Models. These are : (1) Informative-Processing Family, (2) The Personal Family, (3) The Social-Interaction Family, and (4) The Behavioral Systems Family. Since teachers cannot achieve all their purposes through the use of a single teaching strategy, Joyce and Weil (1983) suggest that the wise teacher should master a sufficient repertoire of strategies from all these families. If a given class or teaching situation requires a sudden shift or change in teaching approach, the teachers who are able to use different teaching methods and strategies will be able to do so without fear of losing control over the teaching and learning circumstances.

I have integrated Joyce and Weil's four families of teaching models into one diagram, and Stokes and Crawshaw's (1986) four teaching methods and strategies for environmental education into another, to demonstrate how maximum teaching effectiveness might be achieved. My reason for this is based on the fact that ecology is a subject that targets the attitudes and the ideas of students concerning human interaction with the total environment, both biological and physical components. Thus, it requires a multi-involvement oriented teaching approach that engages the students in a close examination of their attitudes toward nature and seeks at the same time to dramatize the various components of the earth's ecological balance through activities designed to allow them to encounter and play out different, and perhaps contrasting ecological perspectives. This requires for example, that the students in an ecology class play the role of scientists, lawyers, judges, defendants, environmentalists, active participants in dramatic encounters, etc. If teachers want to use role-playing in teaching ecology, they cannot rely on lectures and memorization of dry collection of facts and theories and objectivity alone, they must also integrate some combination of, for example, inquiry, syntactic, jurisprudential, awareness training, group discussion, debate, problem-solving and investigation models, etc. It is in the light of integration such as this that I looked at Joyce and Weil's four families of teaching models in one diagram as well as Stokes and Crawshaw's (1986) four teaching methods and strategies for environmental education.

Stokes and Crawshaw (1986) identified four target groups for tertiary environmental education, the Technical Group, the Subject Specialist Group, the Management Group and the Lay Group. They wrote:

> Each of these groups requires different sets of skills and abilities. The Technical Group needs to know how to measure environmental parameters. The Subject Specialist Group needs to know about environmental systems. The Management Group needs to have the skills and abilities to resolve complex environmental issues and problems. The Lay Group needs to have attitudes, philosophies and values about the environment. Each of these in turn require different teaching strategies. For the Technical Group, practical experimental teaching methods based on the traditional subjects approach appear to be the most suitable. The Subject Specialist Group needs presentational methods based on either an infusion approach or a new subject approach. For the Management Group, a combination of high level disciplinary teaching combined with intensive short skills courses and more extensive 'junction' or 'environmental encounters', all of which make use of practice methods of teaching, are suggested. For the Lay Group, experiential methods, where the student's attitudes are challenged by experiences in either an in-service situation or through simulation exercises, seem to be most appropriate. (p. 35)

Since secondary school science students might belong in the near future to one or more of these four groups, then a useful teaching method should include the integration of a variety of teaching strategies from the above four mentioned groups as shown in figure 7.3.

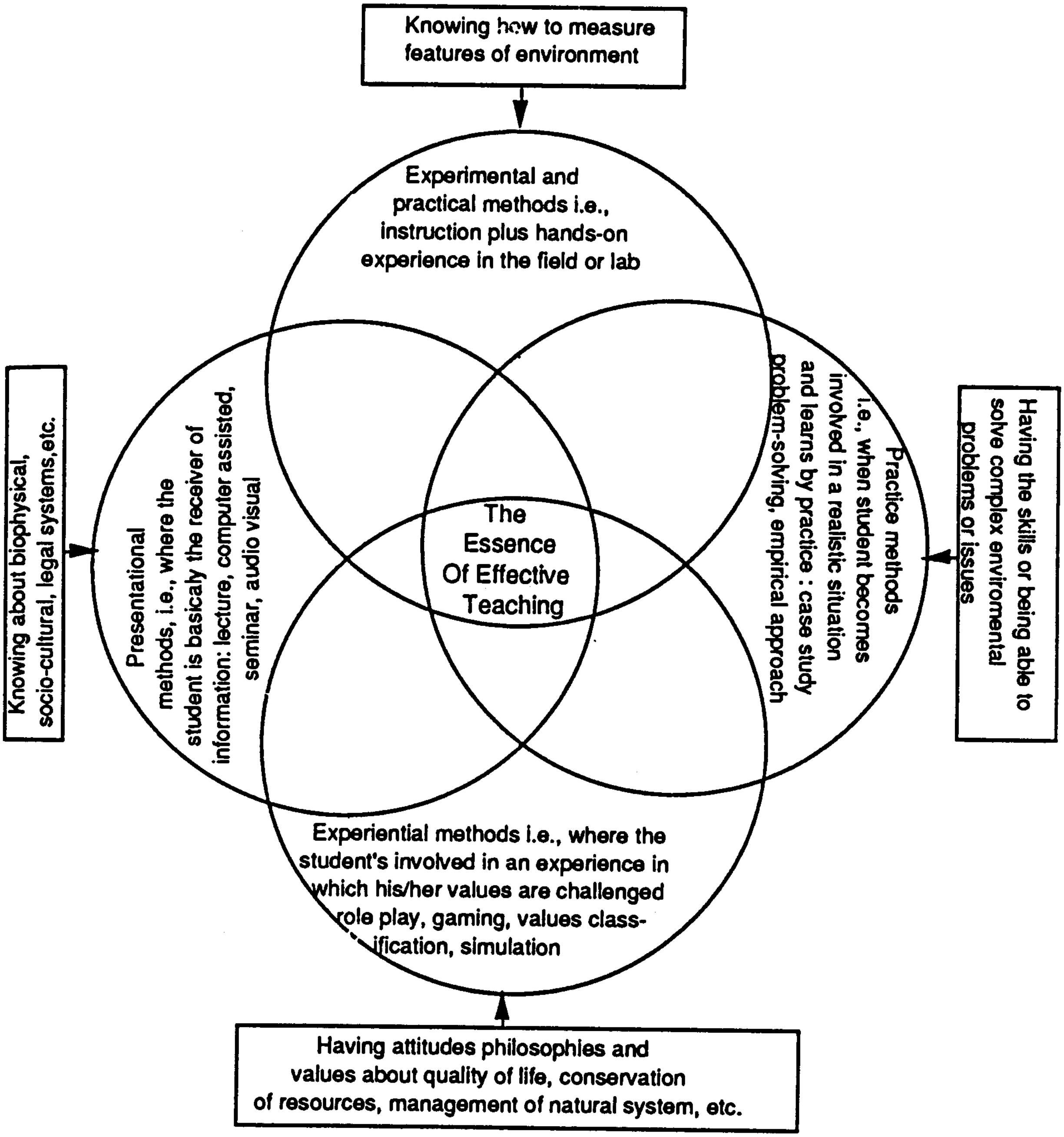

Figure 7.3 This diagram shows the teaching methods and strategies for environmental education suggested by Stokes and Crawshaw (1987)

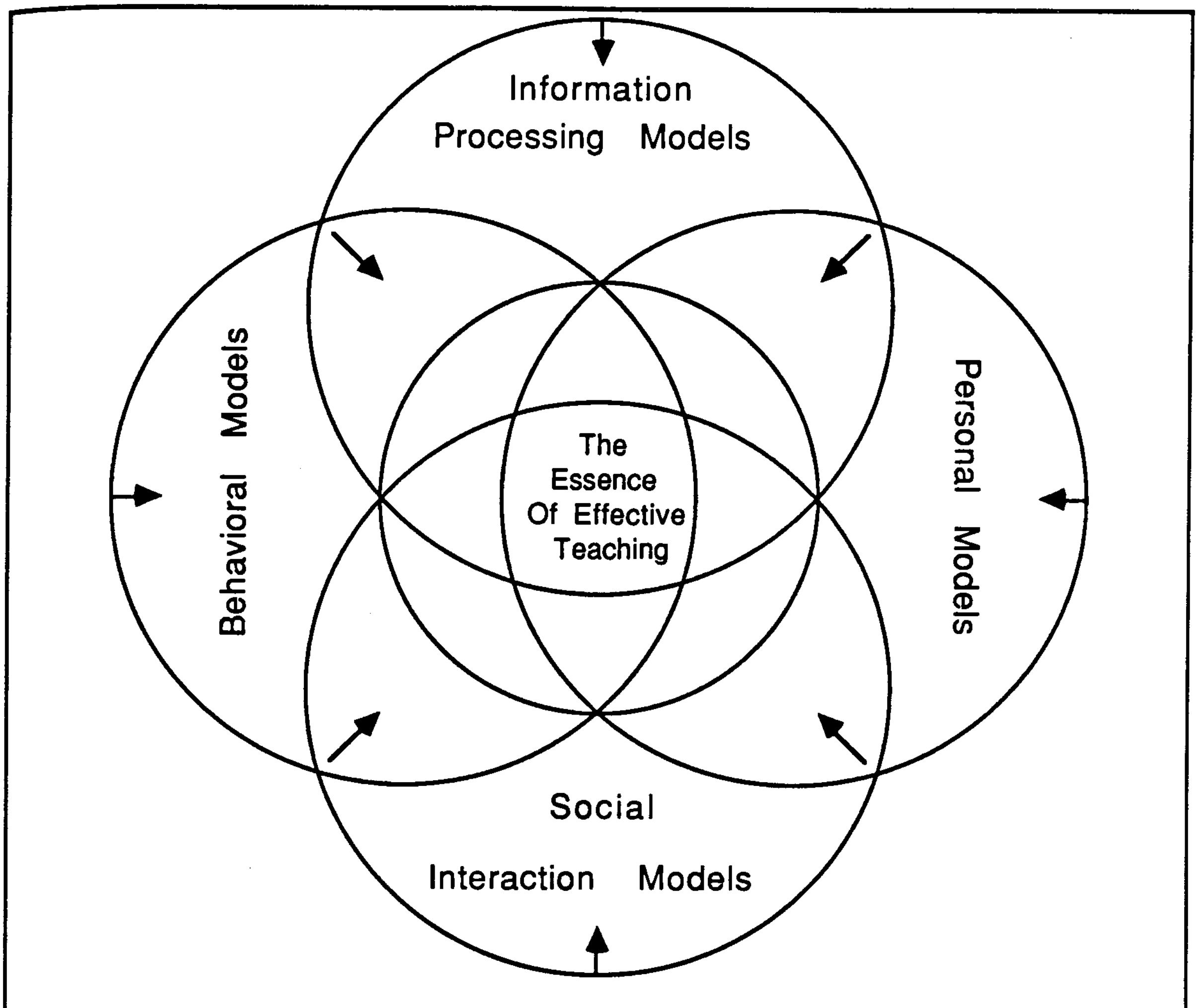

Figure 7.4 This diagram shows how the Joyce & Weil's (1983) families of teaching models can interact and overlap. It also shows how teachers can move toward and achieve the essence of effective teaching by using as many-but only as many-teaching strategies as necessary to ensure children's satisfactory effective learning and teacher's satisfactory effective teaching.

Figure 7.4 shows how Joyce & Wiel's four families of teaching models interact and overlap. The center of the diagram represents the essence of effective teaching which is the result of a variety of approaches to learning and teaching. The closer that teaching takes place to the center of the diagram, the higher chance of the possibility of conducting effective teaching and the greater the opportunity for students to learn (effective learning). Thus, teachers should always aim to be in the center or at least to progress toward the center (the essence of effective teaching). To achieve this state requires not only familiarity with all of these four families of teaching models, but also with which ones to use in a given situation. Those who understand the nature and the objectives of the families of teaching models most likely will be more willing to try to adap various teaching methods based on a result of review of possibilities rather than on familiarities (e.g., Pratt, 1980). As a consequence, they will be better equipped to achieve the essence of effective teaching (the center of the diagram) than, those who are familiar with only one family of teaching model.

Table 7.2
Some alternative chooses of teaching strategies for selected ecological topics.

Subject	Families of Teaching Models	Teaching Models/Strategies
Ecological History	Information-Processing Social Interaction	Advance Organizer, Concept Attainment, Inductive Thinking
Basic Fundamental of Ecology	Information-Processing Social - Interaction Behavioral Systems	Scientific Inquiry Concept Attainment, Inquiry Training Group Investigation
Human Ecology	Social - Interaction Personal Family Group Information-Processing	Social Inquiry,Synectics, Investigation, Debates Classroom Meeting, Awareness Training.
Evolution	Information-Processing Social - Interaction Personal Family	Classroom Meeting, Inductive thinking, Concept Attainment, Non-directive teaching.
Ethics of Ecology	Social - Interaction Personal Family Behavioral-Systems	Group Investigation, Role Playing, Synectics, Social Inquiry, Debates, Classroom Meeting, Awareness Training, Jurisprudential
Environmental Behavior	Social - Interaction Personal & Behavioral Information-Processing	Role Playing, Inquiry Training Classroom meeting, Awareness Training, Group Investigation.
Urban Ecology	Social-Interaction Personal Family Information-Processing	Jurisprudential, Social Inquiry Group Investigation, Scientific Inquiry, Synectics, Awareness Training.

I propose that a multi - teaching model that allows for full student-teacher involvement in the teaching-learning situation and aims at worthwhile knowledge and understanding is what should be used in teaching the suggested content needed for ecology education. By using Joyce & Weil's four families of teaching models and Stokes and Crawshaw' s teaching strategies for environmental education, I suggest the use of the following teaching models for the matching ecological topics, as shown in the following table 7.2. Therefore, in teaching any given ecological subject, teachers should try to use combinations of many - but only as many - teaching strategies as necessary to ensure both the students' effective learning and the teacher's effective teaching. For example, in developing environmental problem-solving skills teachers can start with teaching necessary ecological knowledge and environmental issues, use case studies to teach what others did/do to solve environmental problems, and then engage students in a real action project to implement and practice what they have learned. Finally, teachers can ask students to compare with a full explanation the procedures they followed and the results they obtained with similar cases.

In the final analysis, however, it seems that effective ecology teaching requires more than just an understanding of, and an ability to select and use, as many teaching strategies as necessary. Teachers themselves must be "...environmentally sensitive and knowledgeable, skilled in responsible decision-making, and active in environmental maintenance and remediation....[They should be able] to assist learners in developing the knowledge, skills, and attitudes prerequisite to participation as citizens in environmental problem-solving" (Volk, 1987, p. 118). They should also take a more active role in educational, social, and political matters as visible environmental educators, testifying at hearings on environmental issues and actively participating in policy development, implementation, and management in environmental organizations. Such involvement enables them (1) to use environmental issues and problems effectively in the classroom; (2) to arrange the necessary conditions and circumstances under which learning takes place; (3) to help students to discover how to become involved, and practise involvement in environmental situations; (4) to help students to become independent and experience self-direction; and most of all, (5) to serve as "an important model of citizen involvement to colleagues and students" (Cellarius, 1987, p. 219).

CHAPTER EIGHT

PLANNING FOR ECOLOGICAL EDUCATION

In this chapter, I discuss the social environment in which the proposed model for ecological education or similar ones can be planned, developed and implemented, as well as how the proposed framework for ecology education can be constructed and implemented. I then clarify this framework as an interdisciplinary curriculum using selected educational characteristics.

The Social Environment For The Proposed Model of Ecological Education

There are two general prerequisites for developing and implementing this model in a given society: first an appreciation of the role of education in society, and second, the unwillingness of a society to live with environmental problems. These two prerequisites are important in creating a hospitable social environment for the emergence, acceptance, and implementation of a new perception which is always rooted in the rise of social needs.

Society must believe that, in the long run, change can be brought about through education and schooling. If educational efforts are focused on ecological problems, change will likely take place in the attitudes and behaviour of individuals. If there is the will, knowledge, and resources to do an effective job, education and schooling can have a powerful and lasting effect on children (e.g., Joyce and Showers, 1987). Society should not underestimate how much children can learn or just how powerful education and schooling can become both in developing educated minds and supplying the manpower necessary for societal needs. The history of education in North America shows that formal education has been perceived as one means for removing the obstacles on the road to solving social problems as well as a way up the economic ladder (Sewall, 1983; Greene, 1985). The history of education in North America also shows that the reforms of science education have always taken place as a result of new societal demands. For example in the late 1800's when the United States experienced agricultural depression which resulted in massive population migrations and increased unemployment in large cities, many turned to science education (specially nature study) for enhancing interest in farming among school children (Bybee, 1977a)[1]. The call for emphasizing the methodological aim of science education between 1920-1940 was at least partially "...associated with the need to solve the many societal problems" (Bybee, 1977a, p.90). Again, in the 1960's American society turned to science education for possible solutions to the science manpower needed for the space race as well as for the more rapidly growing scientific-technological society. So, even though public schools in an open democratic society are primarily educational institutions (Kazepides, 1987), they have adjusted to meet external demands in the past and can again.

The second prerequisite is that a large number of the members of a given society must express their unwillingness to live with environmental problems that threaten their survival and quality of life. They must express this by a willingness to put massive resources into supporting research, and training more people to help society deal with its increasing serious environmental problems. Fortunately, North Americans are becoming increasingly aware of the need to protect the natural environment and to sustain life in a healthy ecosystem. For example, a) an opinion poll shows that "...over 90% of Canadians believe that every major economic project should be proven environmentally before it should be allowed to progress" (Potter, 1988, p. 82); b). today, Canadians are willing to pay more taxes in order to live in a clean environment than ever before and to pay more for products that do not harm the environment (Environment, Sept. 1988, p. 47)[2]; c).as a nation, Canada has excelled in its extensive range of high quality informative publications

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1- "Nature Study" Lawrence Cremin (1962) wrote, was perceived as"...the great remedy for the alienation of [hu]man from the land and from his[her] neighbour"(Cited in Bybee, 1977a, p. 87-88).
2- cf., Eco/Log Week, July 8, 1988.

which focus on environmental technology and legislation which are intended for generating high standard of interest and awareness in the environmental among a scientific, technical and governmental-oriented leadership (Potter, 1988, p. 82). Moreover, major banks and governmental agencies are more willing to listen to ecologists and/or to appreciate the idea of linking conservation with development (McNeely, 1988). The growth in wetland-use regulation in North America is another indication that society has began to understand the importance of preserving ecologically critical land and resources (Hunter, 1988).

Thus, if society expects students to develop positive ecological attitudes and the ability to take intelligent action, then: first, society must express its desire for education to generate widespread awareness of environmental issues in society, and second, society must express its desire for survival and quality of life in a healthy ecosystem and then determine and support the educational goals that might lead to these basic human needs. When the proper goals are determined, they need to be translated into teachable and attainable classroom aims and objectives. From here, the proper educational content that promotes the accomplishment of the established objectives, aims, and goals can be developed. The content and experience of ecology education could then be effectively taught to the coming generation. If all the previous steps are taken, then the initial behavioral outcomes, to promote desirable environmental awareness, attitudes, and responsible environmental action among individuals, would likely begin to appear among students. These environmental attitudes could lead to the formation of environmental groups which ideally could then lead to an ecologically responsible society, and hence to an improved environment. This sequence of events will not be easy to achieve because of the effects of various social factors (Bybee, 1977a) or situational factors.(Hines, et. al ,1986).

How The Framework of Ecology Education Can be Developed and Implemented

A conceptual working map for the proposed ecology education curriculum and how they interact as a curriculum model for ecology education consists of five levels: goal level development, content level development, instruction level development, outcome level development, and the level of the social barriers in ecology education development and implementation.

I- Goal-Level Development

The success of any venture depends largely on the goals established in the beginning, which should be stated clearly and objectively. Since the long-term purpose of eco-education is to develop an ecological society through schooling, then it makes sense to begin at the goal level development. In educational planning and development, the goals must be stated in a clear, realistic, and worthwhile setting (e.g., Kazepides, 1987) and as well, the goal statements must direct the selection and the treatment of the content and how to teach it. This implies two things: first, a translation of the long-term goals into several basic instructional statements aimed at the development of ecologically informed citizens. Second, since before undertaking a truly inventive solution one must understand the problem, those educational policy makers, educational philosophers, and educators who are responsible for breaking down the long term goals into teachable educational goals, must be aware of the true nature of ecology, the purpose of ecology education, environmental issues facing human society, and historical and pedagogical factors that led to the present ecological conditions. This is very important because the first step in finding a pedagogical solution to the problem of developing an ecological society, (to borrow Lewis Rhodes'(1988) words from another context) always take place in "education's true work place--the minds of its decision and policy makers" outside the classroom. If those professionals are unaware of such important issues or where the task is leading, then their effort to fulfill the purpose of ecology education will be ineffective and might lead to further confusion in development, implementation and, evaluation of the curriculum and its outcomes.

II- Content - Level Development

When the long-term goals are broken down into instructional statements, then these teachable goals and objectives need to be interpreted into specific ecological content and experiences to take place in the classroom. The ecological content and experiences must be carefully chosen for their educational value to fulfill the true nature of ecology and the main purpose of ecology education. In ecology, both what we teach and how we teach are important and, thus, the educational planners, curriculum developers, and textbook writers and publishers must be aware of the true nature of ecology, the purpose of ecological education, and environmental issues human society faces, as well as what/how other societies and civilizations do/did to solve environmental problems and maintain (or were unable to maintain) an ecological society.

This thesis, based on a careful analytical study, proposes the following ecological content: ecological history, basic fundamentals of ecology, human ecology, evolution, eco-ethics, environmental behaviour, urban ecology and other related topics. Themes such as these are believed to have high educational value to fulfill the pedagogical demands of the goals of ecological education necessary for developing an ecological society.

III- Instruction - Level Development

Ecology deals with various knowledge and experience from both the natural and social sciences, and thus, it makes sense that teachers be able to use a combination of many teaching strategies such as scientific inquiry, problem-solving, project action, field trips, lab experimentation, debate and discussion, demonstration, investigation and discovery, etc, in their ecology teaching. It has been said that:

> If variety is the spice of life, then it surely is the "salt and pepper" of teaching. Even the most exciting content can become dull if it is approached in the same way day after dreary day. (Jacobson & Bergman, 1987, p. xiii)

In order for teachers to be able to use the right combination of many teaching techniques, they must be familiar with different teaching models and the nature of the teaching techniques associated with those models (e.g., Joyce & Weil, 1983); aware of the true nature of ecology and the purpose of ecology education.

IV- Outcome - Level Development

Since most of our attitudes are culturally and/or educationally learned or acquired, then if the appropriate ecological goals, content, and teaching procedures, are developed, designed, and implemented respectively without any barriers, change will likely take place in the behaviour of individual students. They will develop a fundamental understanding of ecology and ecological systems and issues, as well as a sense of responsibility for their actions and acquire the skills and experience necessary for solving environmental problems. The accumulation of such understanding, attitudes, and responsible action will eventually promote the development of the ecologically informed citizenry that will be necessary for developing an ecological society. Members of this society will share and enjoy an improved quality of the environment and of life. However, in order for them to maintain such quality of life for themselves and their children, they must continue to support the development of ecological education through the development of goals, content, and teacher training and the removing of all the barriers to effective ecology education. The cycle will thus continue again from level I to level IV until new societal needs surface and a new perception appears (Bybee, 1979b).

V- Barrier - Level Development

Regardless of how worthwhile the goals of ecology education, and how sophisticated the teaching procedures and teaching materials to achieve the desirable learning outcomes, if there are barriers that harden the job of the educational professionals and educators, we can neither teach ecology nor fulfill the purpose of ecological education. Many social factors might influence the educational processes of ecological education at any level. Some of these are various economic constraints, social pressure, political will (or the lack of it), democracy and its limitations, polluting industries, government support of such, cuts in environmental or educational budgets, social attitudes toward the environment, etc. The effects of such factors extend to all the components and the levels of the proposed ecological framework. For example, the educational philosophers who determine the goals of ecological education have to answer to the government and other agents who fund them. They need sufficient support from the public as well as from their colleagues in related disciplines, especially science and ecology, in order to challenge the Ministry of Education, and other agencies and parents, in their efforts to lead public schools to achieve or abandon educational goals of ecology education. Outspoken educational professionals could be replaced by others with either less integrity or less awareness of ecology and its educational demands if their educational recommendations do not fit with the policy of the sponsors. Thus, the goals and aims of ecological education need a supportive public and an aware and united educational and scientific community that can maintain its integrity in the face of any social, political, or economic barrier.

The selection of textbooks for an ecology curriculum represents another barrier. To be fully effective, ecological education requires ecology textbooks specifically designed to fulfill the purpose of that particular ecology curriculum. With increasing cutbacks in educational budgets, curriculum supervisors have been asked to choose from existing biology and ecology textbooks. It is easy to imagine that these curriculum supervisors might be forced to believe that all the texts are alike and look for publishers who give the best deal or the 'freebie' package rather than strive for educational primacy.

Orientation and Nature of Objectives

In this section, I clarify the proposed ecology curriculum as an interdisciplinary program using (a) Dukacz's & Babin's (1980) curriculum orientation profile and Eisner's (1985) five basic orientations to the curriculum: development of cognitive processes; academic rationalism; personal relevance; social adaptation / social reconstruction; and curriculum as technology; (b) Hungerford, Peyton and Wilke's (1980) four goal levels of environmental education for curriculum development: Ecological Foundation Level; Conceptual Awareness Level-Issues and Values; Investigation and Evaluation Level; and Environmental Action Level- Training and Application; and (c) Bloom's taxonomy of educational objectives: knowledge, comprehension, application, analysis, synthesis, and evaluation.

Eisner's five basic orientations to curriculum provide a useful framework for an analysis of curriculum. As stated in chapter six, I feel that each of these basic orientations to curriculum have a direct bearing on the kinds of opportunities for learning that students are provided with and that the provision of learning opportunities is probably the single most important factor influencing the content of learning in school. Thus, since each of Eisner's orientations to the curriculum is designed for different learning situations, and ecology is interdisciplinary, then it is important to integrate some of the most relevant components or ideas of all the orientations in one curriculum.

In clarifying the orientation towards the content, goals and organization of the proposed ecology curriculum, I applied first, the characteristics of Eisner's (1985) basic orientation to curriculum, and second Dukacz's and Babin's (1980) suggestion of using "Curriculum Orientation Profile' or do-it-yourself' quiz which uses the categories of orientation to curriculum developed by Eisner and Vallance (1974). Using criteria such as this, Dukacz and Babin (1980) believe it "may help...[educators] decide to emphasize one area of the proposed curriculum because it is compatible with ...[their] beliefs; to de-emphasized a second one because it conflicts with them; or to amend a third so that it is more in line with what they think[themselves]..." (p.16). In doing so, first, I related the proposed ecology curriculum as a whole into the characteristics of Eisner's (1985) five.orientation of curriculum and then to the Dukacz's and Babin's (1980) curriculum orientation profile. Second, I applied each main topic of the proposed content into Dukacz's and Babin's (1980) orientation profile by critically going over the context of a given topics as well as the characteristics of each of Eisner's basic orientations to the curriculum. The results of these analysis is shown in table 8.1

The ecology education program proposed in this thesis is developed to bring about a particular kind of learning in ecology and its related disciplines. It is also designed to reflect all of Eisner's (1985) five basic orientations to the curriculum. Tables 8.1 & 8.2 match specific elements from the proposed goals, aims, objectives, and/or content of ecology education to a related one, or more, of Eisner's basic orientations to the curriculum. It is clear from tables 8.1 & 8.2 that all of Eisner's basic orientations are incorporated into the proposed curriculum. Overlap of course exists. For example, and based on the characteristics of each one of these five basic orientations, developing global minds, ecocentric attitudes and beliefs, maintaining ecological equilibrium, developing scientific attitudes, desirable environmental attitudes and behaviour, and fulfilling human and social needs, education about ecological ramifications and moral issues, can all be categorized under social adaptation and reconstruction. But, developing some of these objectives (scientific attitudes, personal and human needs, and desirable attitudes and behaviour to the environment, etc.), can also be classified under personal development. Thus, the different goals, aims, objectives, and topics of this ecology education proposal reflect more than one curriculum philosophy. For example, in order to be educated about the ecological ramifications of our decisions we must know how to motivate ourselves and consider what is relevant to ourselves (self-acualization). We must be aware of possible ramifications (academic rationalism), and have the ability to understand and to determine the goals toward which we think society should work (social adaptation/reconstruction), the ability to analyze, compare, and predict different ramifications (development of cognitive processes). Furthermore, we must not only be aware, for example, of the ramifications of industry's influence on ecology, but also be capable of making educated and responsible environmental decisions regarding them. Once decisions have been made, we need to know how to put our plans into intelligent action.

The second criterion for clarifying the proposed ecology education curriculum is Bloom's taxonomy of educational objectives which are knowledge, comprehension, application, analysis, synthesis, and evaluation. This taxonomy of educational objectives as stated in chapter six, provides a framework around which educators and teachers can examine congruency in the classroom or in a curriculum guide. Each category is assumed to require students to demonstrate thinking behaviour more complex and abstract than in the previous category. This means that the categories are arranged from simple to complex behaviour and from concrete to abstract thinking. Every educational program should be designed, implemented, and its student-learning outcomes should be evaluated with consideration to each component. From a close look at the core content of the proposed framework for ecology education (table 8.3), it is clear that the proposed program is designed toward developing all components of Bloom's taxonomy as a whole and as single units.

Table 8.1
The relationship between Eisner's five basic orientations to the curriculum and the goals, aims, and objectives of the proposed ecology education curriculum

Eisner's Basic Orientations To The Curriculum	Goals of E.E.	Aims of E.E.	Objectives of E.E.
Development of Cognitive Process.	4, 2	5	4,9
Curriculum as Technology.	5, 2	-	5
Self-acualization/Personal Development.	3	3	3, 8
Social Adaptation/Reconstruction.	G.G., 5	2, 4	6, 10
Academic Rationalism.	G.G., 1	1	1, 2, 3

G.G. means the general goal of ecology education which is to develop ecological societies that are able to establish, develop and maintain a state of global equilibrium. The numbers under the goals, aims and objectives refer to the statements of the goals, aims and objectives stated in chapter seven.

Table 8.2
The relationship between the core content of the proposed ecology education curriculum and Eisner's five basic orientations to the curriculum

A Core Content of E.E.	Eisner's Orientations to The Curriculum
History of Ecology	Academic Rationalism/Self-actualization.
Fundamentals of Ecology	Academic Rationalism.
Human Ecology	Cognitive Process/Self-actualization.
Evaluation	Academic Rationalism.
Ethics of Ecology	Social Adaptation & Reconstruction Cognitive Process/Academic Rationalism.
Ecological Behaviour	Social Adaptation/Reconstruction, Cognitive Process & Curriculum as Technology
Urban Ecology	All Five Orientations to The Curriculum.
Other Related Topics	Curriculum as Technology

As demonstrated in table 8.3, the whole core content of the proposed ecology education is designed so that the ecological history will provide or lead to awareness, recognition, and knowledge; basic fundamentals of ecology will provide or lead to recognition, knowledge, and comprehension; human ecology and evaluation will provide or lead to recognition, knowledge, comprehension and application; and ethics of ecology, ecological behaviour and urban ecology will lead to application, analysis, synthesis, and evaluation.

As separate units, each is designed to incorporate most elements of Bloom's taxonomy. For example, while the 'ecological history' is expected to develop awareness, knowledge, and recognition among students, the examination of the recent changes in the environment of landscape (e.g., desertification, deforestation, erosion and salt pollution, de-diversification or extinction, etc.) all require the ability to apply, synthesize, analyze and evaluate given circumstances before making any moral judgments or decisions. These higher elements of the cognitive domain of Bloom's taxonomy are important if learners are to provide alternative solutions to any given problem.

Table 8.3
The relationship between the core content ecology education and Bloom's taxonomy of educational objectives

Topics of E.E. Objectives	Themes of Ecology Education	Bloom's Taxonomy of E.
History of Ecology	History of the earth. History of local fauna and flora. History of our species. History of human civilization. History of the recent changes of environmental morphology.	Awareness Knowledge Recognition
Basic Fundamentals of Ecology	The laws of ecology. The structure of the ecosystem. The mechanism of ecology. Mathematical ecology.	Knowledge Recognition Comprehension
Human Ecology And Evolution	Human nature. Human values & human institutions. Sustainability & sustainable society. Man's place in the natural world.	Recognition Comprehension Application
Ethics of Ecology	Relation among human beings. Human treatment of non-human living organisms. Relation between humans & nature.	Awareness/Knowledge Application Analysis/Synthesis Evaluation
Ecological Behaviour	Cognitive knowledge of environmental problems. Cognitive skills.	Application Analysis/Synthesis Personal factors. Evaluation
Urban Ecology	Relevant Knowledge, Process of decision-making, Value judgement, providing alternatives and participating in solving problems. Drawing Conclusion/ Making - Decisions/Providing alternatives.	Application. Analysis/Synthesis/ Evaluation.
Other Related Topics	Natural resources. Future sources of energy. Bio-technology and environment.	

Basic fundamentals of ecology represents another example of how single units can incorporate most of the elements of Bloom's taxonomy. This unit provides students with the ecological principles, concepts, and scientific background vital for dealing intelligently with social and environmental problems and issues. Thus, this unit will develop knowledge, recognition, and comprehension among students. For example, the theme of mathematical ecology requires the ability to synthesize, analyze, and evaluate at a higher level (cognitive domain) of Bloom's educational objectives.

'Urban ecology' which also requires these higher elements (application, analysis, synthesis, and evaluation), provides still another example of how single units can incorporate most of the elements of Bloom's taxonomy. In order for the learners to be able to analyze, synthesize, and evaluate a real environmental problem in the urban environment, they must not only be aware, knowledgeable, and comprehensive, but also should be able to use and apply everything they have learned in previous units and other disciplines. This of course is also true for the units of 'ethics of ecology', 'ecological behaviour', and other related topics. The proposed framework, then, can be seen as comprehensive in light of Bloom's cognitive domain.

The third useful criterion in clarifying the proposed framework for ecology education is Hungerford, Peyton and Wilke's (1980) four goal levels of environmental education. These four goal levels are important because (a) they represent a useful structure for science curriculum analysis (Staver & Pay, 1987), (b) they reflect the Tbilisi Declaration[1] objectives of environmental education, (c) they share primary common ground with the general goals of science education proposed by both Project Synthesis[2] of the United States and the Science Council of Canada report, 35 (1984)[3], and (d) they were stated in a way so that various elements of eco-education could be evaluated.

1- The broad objectives of the Tbilis Declaration (1978) include " The development of an awareness and sensitivity to the environment and its problems, a knowledge of the environment and its problems, attitudes of concern for the environment and motivation for participation in environmental improvement/protection, skills requisite to identifying and resolving environmental problems, and participation in environmental problem solutions" (Volk, 1984, p. 26).

2- Project Synthesis proposed four goal clusters for science education : (1) to prepare individuals to use science in their lives to cope with technology, (2) to prepare informed citizens to repond to science/society issues, (3) to academically prepare those intending to pursue science, and (4) to produce an awareness of the science and technology careers that are open to a variety of people (Volk, 1984).

3- The Council concluded that science education should be directed towards (1) preparing citizens to participate politically and socially in a technological society, (2) preparing students to pursue lifelong learning (especially in science/technology and its relation to life), (3) preparing young people adequately for the world of work, including the necessary training for those intending to enter scientific and technological fields, and most importantly (4) developing rational, independent-thinking and responsible individuals.

In 1980, Hungerford, Peyton and Wilke put forth four goals which reflected environmental educational thought and would guide curriculum developers. These four goals can be summarized as follows: (1) providing ecological knowledge to permit the formulation of sound decisions on environmental issues (Ecological Foundation Level), (2) guiding the development of an awareness of our actions, the environmental issues resulting from our actions, and the processes needed for resolving the issues (Conceptual Awareness Level), (3) involving students in investigating environmental issues and evaluating possible solutions (Investigation and Evaluation Level), and (4) training students to be environmentally responsible and active (Environmental Action Skills Level). After each statement of the proposed goals, aims, objectives and core content was written, each was carefully read, examined, and classified as ecological foundation, conceptual awareness, investigation/ evaluation, and/or environmental action skills. The result of the analysis is summarized in table (8.4).

Table 8.4

The relationship between the proposed goals, aims, objectives, and core content of ecology education and Hungerford's, et al (1980) four goal levels of environmental education development

Four Goal Levels of Environmental E.	The proposed Goals	Aims	Objectives	Content
Ecological Foundations	1	1	1, 2, 3	All Topics
Conceptual Awareness	4	2, 5, 3	3, 5	1, 3, 5, 7
Investigation/Evaluation	2, 4	5	4, 9	5, 6, 7
Environmental Action Skills	3	4	5, 6	6, 7

The numbers under the " Content" column refer to: 1= History of Ecology, 2= Basic Foundation of Ecology, 3= Human Ecology, 4= Evolution, 5=Ethics of Ecology, 6= Ecological Behaviour, 7= Urban Ecology, and 8= Other Related Topics. The numbers under the goals, aims and objectives refer to the statements of the goals, aims and objectives stated in chapter seven.

As demonstrated in table (8.4) the goals, aims, objectives, and core content of the proposed ecology education curriculum cover all four goal levels proposed by Hungerford, et.al (1980). The proposed curriculum places great importance on the awareness of issues and the need for personal fostering and social responsibility. It emphasizes the need for using scientific inquiry as an essential tool for the investigation and evaluation of environmental issues, and focuses on developing individuals who are knowledgeable about science-related societal issues, and who are competent to engage in their investigation, evaluation, and resolution. Furthermore, as Volk (1984) convincingly argues, science education goals and environmental education goals have a common perspective and environmental education would be a valid usable resource to meet science curriculum goals. If a strong common ground and relationship exists between the four goals for curriculum development in environmental education (Hungerford's et. al,(1980) and the Project Synthesis' four goal clusters of science education (Volk, 1984) as well as the goals of science education proposed by the Science Council of Canada (1984), then the concept behind the prospective framework for ecology education proposed in this thesis is closely related to the goals set out for science education in general in both Canada and the United States.

Based on those clarifications, the proposed framework for ecological education is far more than reorganized catalogues of items of content. Its goals have been clearly, realistically and objectively stated as short and long term worthwhile goals, aims, and objectives. Its content has been carefully chosen and treated to have a high educational value, and its teaching strategies have been carefully selected to meet the demands imposed by the nature of ecology and the purpose of ecological education. The proposed curriculum provides a balance of reliance between the structure of the discipline and its relevance to societal problems , as well as application in everyday life.

The final chapter which follows provides conclusions, and recommendations which I believe will present a new challenge not only in the field of science and ecology education but in the field of education in general.

CHAPTER NINE

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

To date, society has only achieved a partial understanding of the global ecological system. The decisions we have made in the past fifty years bear this out. We have remained steadfastly ignorant of the consequences of our actions and our technology, and insensitive to the limitations of the earth. As a consequence, over time, monumental environmental catastrophes have occurred, for example the widespread practice of clearcut logging in the Nass Valley, much of Lyell Island, the Kootenays, and elsewhere have caused soil erosion, avalanches and siltation of local creeks and lakes (Harrington, 1988; Wynn, 1988). This sort of behaviour shows that B.C's forest industry along with other foresters in many parts of the word, have not yet understood, or likely even considered, the merit of Leopold's land ethics, "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise."[1] We must learn to understand how to live within the bounds of the global ecological system in a non-destructive manner if we wish to survive, much less impart to future generations a quality of life comparable to that which we enjoy today.

Although educational concern for environmental issues materialized in the 1960's, judging by current ecological conditions it does not appear that we have learned much or that any of our efforts at improving the environment have been particularly successful. This study began with two very broad questions: 1) Why have these environmentally oriented programs not produced a more ecologically responsible society? 2) Why does society not take effective action towards alleviating ecological crises until they affect both

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1- Indeed, while B.C. Foresters"...struggle with the ethics of sacrificing professional principles to save jobs" (Wynn, 1988, p. 159), they have been accused of ignoring what is said to be most important in their code of ethics(Harrington, 1988). According to this code, a forester "...will, in all aspects of his work, regard as his first responsibility the maintenance of the integrity of the forest resource; the protection and enhancement of the productive capacity of the resource; its perpetuation; and the improvement of its utility and value to society". Obviously, there is no relationship between the ruthless clear-cutting and slash-burning that is taking place all over British Columbia and the maintenance of the integrity of the forest resource."(Harrington, 1988, p. A7) the quantity and the quality of our basic survival needs? Implicit in both these general concerns is the specific question, why are our educational programs ineffective in changing our attitudes and behaviour towards the natural world and global ecology? The following possible reasons were suggested: 1) lack of educational concern among ecologists; 2) lack of environmental concern among educators and philosophers; 3) lack of related anthropological and archaecological knowledge in ecology education; 4). lack of emphasis on teaching evolution in secondary school curriculum; 5).lack of a holistic view of ecological education; 6) lack of the essential characteristics necessary for an adequate ecological education; 7) lack of a distinct place in the school curriculum; 6) lack of preparation for intelligent action; and, 7) many specific existing barriers in the teaching of ecology.

Evidence shows that while many citizens display a high degree of verbal commitment to environmental issues, they posses inadequate ecological knowledge and a low degree of actual commitment to act intelligently on environmental problems (Nichols, 1980). This situation is probably due to the fact that layman usually get their knowledge on environmental issues from media and social gatherings. With this limitation, they lack an accurate ecological understanding of the natural world (Barber, 1982; Bluhm, 1975; Sale and Lee,1972), and also lack the motivation and insight to change attitudes that might result in a change in the care and respect for living things and of the environment. The average citizen has not been taught to see beyond his/her lifetime. Public attitudes and awareness are usually born and nurtured in primary and secondary school where, if there is little or no ecological education, then, apathy arising from lack of knowledge becomes a typical reaction to ecological issues. Pupils' attitudes toward the environment and its components "...will only get a chance to develop by progressive exposure to living things and environments and with the influence of other people's caring attitudes especially those of teachers" (Cade, 1988,p.159).

A lack of ecological knowledge, vision, and/or related scientific and technological knowledge among the citizenry extends beyond the average person to include some public school teachers and administrators (Schafer, 1987; Bluhm, 1975), some engineers (Schoenfeld, 1970), many politicians (Suzuki, 1987), and even some environmentalists (e.g., Devall, 1988; Barber, 1982; Kuperhella and Levy, 1975). Of those who do have the necessary ecological knowledge and vision (e.g., ecologists, biologists, anthropologists, geographers), only a few have really involved themselves in the educational aspects of environmental issues and problems.

This study examined the status and the nature of ecology within biology education at the senior secondary school level in British Columbia. It determined and discussed what various educators think ought to be the nature of ecology education, and identified the discrepancy between ecology as it exists within biology education today and what ought to be the case. Finally, the study proposed and developed a prospective framework for ecology education to be implemented at the secondary school level.

Discussion and Conclusions

This study showed that there is a discrepancy between ecology as it is understood in the 1986 Bio 11 & 12 curriculum in B.C. today and what various educators (including B.C. teachers) believe ecological education ought to be. This discrepancy includes:

1. As I argued in chapters three and seven, to be fully effective, ecological topics must be integrated into core curricula as required offerings and/or a distinct course for environmental sciences. Most present ecology and ecology related subjects in the Bio 11 & 12 program, however, are in the optional section of the curriculum. Moreover, while the 1974 Bio 11 & 12 program was ecologically oriented, the 1986 Bio 11 & 12 program is biologically oriented with less core-emphasis on ecology, especially on man's management of and man's role in ecological processes and interaction with the environment. Why such

a shift would occur in the trend of biology education in B.C. during a period of increasing environmental concern and renewed interest in a whole-earth remains an open question. What is clear is that: first, regional and global environmental problems are worsening, and solutions for most of those problems require ecological understanding and rational thinking and intelligent action; second, since ecology has been absent almost entirely from the core area of the current Bio 11 & 12 and from high school provincial standardized tests, a thoughtful biology teacher is likely to consider ecology topics and environmental issues as frills.

2. As I also argued in chapters three and seven, to be fully effective, ecological education must deal with both preliminary and long term goals. The short term goals of developing knowledge, awareness and understanding of ecological systems, must be joined by the explicit goal of developing an ecological morality and an ability to respond critically and intelligently to ecological issues. However, a close look at both the cited literature and the 1986 Bio 11 & 12 curriculum guide indicates that developing knowledge and awareness remains the primary and only goal of school ecology. The results of the teacher interviews and teaching observations also supported the fact that goals such as these received most emphasis among all stated goals in the Bio 11 & 12 curriculum guide. (This situation however, is not unique to ecological education alone. Milt McClaren (1988) for example, in a brief to the recently concluded Royal Commission On Education conducted in British Columbia, claims that high school education, in general, is not living up to its stated goals)

3. As I showed in chapters two and three, the literature review indicates that considerable efforts are required to improve the quantity and the quality of the ecological content in biology textbooks. Textbooks must provide adequate knowledge about ecological concepts and principles, and the application of these concepts to environmental issues and human life, as well as adequate scientific knowledge about social, cultural,

economic and global aspects of the environment. Textbooks must also provide adequate knowledge about man's role in ecological processes and his interaction with the urban and natural environment. Textbooks should also provide students with an adequate understanding of ecology as science processes. Failure to supply this knowledge and understanding through science textbooks means continued public ignorance and continued damage to the environmental quality of human life.

There is a strong indication from the cited literature, teacher interviews, and the analysis of biology textbooks and the curriculum guide, that the quantity and quality of ecological content in Bio 11 & 12 are not sufficient to produce a productive, protective, and responsible citizenry. Most ecological content deals with the factual aspects of the physical components of the environment. One of the biology textbooks that was highly regarded for both biological and ecological content by many professionals in the field, and developed in cooperation with scientists, educators, and teachers without financial motivation, was the BSCS Green Version (specially fifth and sixth editions). This text had been in use in British Columbia public schools until 1986. Why this text was abandoned as one of the main Bio 11&12 textbooks in a time when biological education in an environmental context is urgently needed in our changing natural world, is a question that remains to be answered.

4. As I argued in chapters three and seven, to be fully effective ecology must be taught through the integration of classroom, field, and laboratory teaching (e.g., Hale, 1962). In teaching ecological topics teachers need to adapt a combination of many teaching techniques such as scientific inquiry, problem-solving and decision-making, discussion and group investigation, reasoning ability, field work and laboratory activities. Case studies and action projects are also needed including knowledge of what others did to solve environmental problem. Teaching techniques such as these are believed to lead to better understanding as well as the application of ecological knowledge to environmental problems and issues. Nevertheless, this thesis concludes that teaching of ecology and

biology is essentially still based on expository techniques consisting of assignment, test, discussion of test and retest. In this traditional expository technique, most of the teachers' lectures depend heavily on textbooks as the primary instructional resource.

While, a large number of British Columbia secondary biology teachers are aware of which teaching techniques are more effective in teaching ecology and biology, they believe external factors contribute to their continued dependence on textbooks and the lecture approach. These factors include, decreased budget for equipment and fieldwork, class size, lack of time, the absence of ecology in the core areas of the curriculum, the inflexibility of the school system, and lack of adequate training in teaching ecology. The results of this study indicate that British Columbia biology teachers are aware of these barriers to effective ecology teaching.

The teaching of ecology in senior secondary school biology classes does not reflect the paradigm of ecology education that emerged from both the literature and the teacher interviews. Given that this is the case, the lack of concern and understanding of ecological problems in society can be seen as a function of inadequate ecological education. However, the results of this study indicate that British Columbia secondary school biology teachers are aware of this situation and have opinions of what should be done. They hold positive opinions toward biology education in an environmental context, environmental issues, and ecological education. The real problem goes deeper than a discrepancy between what is and what ought to be. In addition to this discrepancy, other factors exist which prevent or hinder ecological education from promoting environmental concern and understanding.

To solve the problem of ecological education in British Columbia, therefore, first, this discrepancy must be eliminated by updating the goals and content from related literature. Second, those barriers which hinder effective ecology teaching should be removed. Chapters Seven and Eight dealt extensively with the first point, the following concentrates on the second point: the barriers to effective education in ecology.

Barrier No. 1: The Place of Ecology In school Curricula

This study indicates that British Columbia biology teachers blame the curriculum itself for ineffective ecology education. Currently, ecology topics reside in the optional areas of the curriculum, but because regional and global environmental problems are reaching the critical stage, environmental topics are too important to be left out of the core areas of the curriculum. All students should be taught to think critically and to communicate effectively with their biophysical and social/cultural environment by following a core curriculum based on an ecologically sound philosophy.

Today, ecology is no longer a curious branch of biology for idealistic biologists. It has its rightful place as an important component in the whole educational process. Ecological knowledge is necessary not only to develop an educated mind, but also, like the three R's, to develop literate citizens. There is no further need to dwell on where the place and what the role of ecological education is; it obviously belongs in the forefront, in the core area of the curriculum. We must focus on what ecological education should do to help us develop an ecological society if we want to maintain the quality of our daily lives. No one consciously wants to destroy the environment, but this is just what is happening. Ecology is just as important, if not on the most basic level more important, as reading, writing, arithmetic, science, math, philosophy, history, and language. To be fully effective, ecology must be within the core curricula as required offerings, and take its rightful place in school education.

Barrier No. 2: The Educational System

The educational system has also been considered one of the factors that hinder the teaching of ecology effectively in secondary schools. Waning educational standards and the problems involved in improving a flawed educational system are not new, particularly at the secondary school level (e.g., Goodlad, 1983; Brown, 1984; Perelman, 1976; 1988).

However, because of the complexity and interrelatedness of ecology, more is demanded from school systems in this respect than for the teaching of any other of the school disciplines. For example, to be fully effective, ecology requires urban and natural field work and active participation in action projects which in turn demand extra time, equipment, and flexibility in the school time-table. It also demands a collaborative or team teaching approach as well as team research work. The existing school system does not favor, nor can it accommodate, these innovations, at least not in its present form.

A close look at the history of the schooling in North America indicates that the nature and goals of the school system themselves work against the nature and the goals of eco-education. In their struggle to achieve the American Dream, the early immigrants discovered that the surest way up the economic ladder was through schooling. Today, North Americans continue to look to schools and education as the means for removing the obstacles on the road to material success and upward mobility. The Protestant Ethic that informed such an aim took the view that material success in this world guaranteed a place among the Elect in the next, and these early people took for granted that nature and the environment were designed to serve man. After World War I, the factory model of schooling saw students trained as cogs to turn the wheels of industry while the environment was seen as supplying unlimited God-given raw materials for industries to use. Since then, the school system has been serving industrial and developmental progress without critical consideration of the effect of such progress on the environment. Many legislators, educational policy makers, curriculum developers, textbook publishers, and administrative regulators directly or indirectly have served such factory labor demands. The question remaining is whether North American society will reshape its educational system. If not, what is the alternative?

Successful ecological education is unlikely to be achieved without restructuring or resetting the public school system. Perelman (1988) argues "the one thing that public education cannot have is progress without change" (p. 20). If the curriculum system is revised in such a way as to encourage ecology and environmental science courses, and aims at developing educated citizens able to think critically and act intelligently, then first, the gap between what is and what ought to be will be narrowed; and second, the ecological crises may be brought under control and an ecological society could be achieved.

Barriers No. 3: Ecology Teacher Education

Making the learning of science and ecology more meaningful and enjoyable to most students depends on: 1) the teacher's understanding of the true nature and the structure of science and ecology; 2) the teacher's understanding of the nature, objectives, and processes of different teaching models; 3) the teacher's ability to use less structured teaching approaches; 4) the teacher's ability to connect science and ecology to social, cultural, economic, political, regional and global issues; 5) the teacher's ability to draw out for their students the implications of what has been taught; and 6) the teacher's attitudes toward living things and their environment. For teachers to be fully effective in the teaching of ecology, they need to be trained to enrich the curriculum by adopting these teaching strategies and understanding. Effective teacher education lies in developing teachers who are able to make ecology teaching more meaningful, useful, enjoyable, and learnable.

Although, it is customary for teachers to blame lack of general support and lack of in-service or pre-service training in ecology teacher education in British Columbia, two additional facts are of considerable importance: First, there are few regularly held ecology teacher education courses designed specifically for secondary science teachers, and second, secondary science teachers are notoriously poor attenders of credit in-service courses. While, for example, 5% of about 29,000 teachers in British Columbia have taken the Summer Institutes in Environmental Education at Simon Fraser University, the majority of them were elementary teachers. Secondary teachers, Milt McClaren (1988) explained, "expect to be paid to take courses, and they don't feel that they need credit courses unless they are for graduate credit, so they don't take in-service courses having ecology components". He added, "we have tried at S.F.U. to organize them in the past and have given up because so few enrol."[1]

If this is the case then, the reasons that secondary school science teachers in B.C. do not enrol in in-service ecology education courses are because: 1) they do not feel they lack this kind of training and the new curriculum does not demand it; 2) ecology topics are not one of their main priorities in teaching biology; or 3) they do not feel comfortable with the quality and the objectives of available in-service ecology education courses. Since most of the participants in this study appear to agree that they need more experience in how to teach ecology, and the 1986 Bio 11&12 curriculum guide does not suggest teaching strategies that teachers can choose from, the second and third assumptions seem most important.

Some participants in this study state that whatever is available in in-service ecology education courses or workshops is general and/or deals with factual aspects of ecology. They feel that they need more depth of knowledge about the social and the economic impact of human activities on the environment. They also feel that they need to learn not how to assimilate facts, but to learn how to teach them to develop the ability to think rationale, solve environmental problems, and apply the knowledge and skills learned in one environmental context to other situations. They need help in teaching their students about their role in ecological processes and in the management of the surrounding environment. Because most of ecology and related topics are in the optional area of the Bio 11&12 and are absent from general standardized tests of secondary school science, teachers do not see ecological topics as a main priority in teaching biology, and so see no need to enroll in such courses or workshops. If ecology and environmental issues are one of the priorities of educational policy-makers, curriculum developers, and administrative regulators, then ecology and its related topics will be in a core curriculum of science education, as well as in

1- From written comments on one of the articles I gave to Dr. Milt McClaren to comment on in early 1988.

the general standardized tests of secondary science curriculum. When teaching ecology becomes mandatory for science teachers, then universities will offer mandatory ecology teacher-training courses in their pre-service education programs. Science teachers and student-teachers will be obliged to enroll in these courses because they have to teach the subject,. This action will enhance their own professional growth and development.

Recommendations

In order to be effective, the recommendations for improved ecology education must be based on careful analysis and must also include all the interconnected issues and components of ecology education.

At the level of educational theory and curriculum development

(1) There is a need for a new educational perspective. Since the 1940's, educational theory has been derived from and dominated by a number of disciplines such as psychology, philosophy, history, sociology, and to a lesser extent, economics. Today, educational politics remain the dominant force in decision-making, policy development, and the control of the school curriculum (Nisbet, 1983). The time has come for ecological principles to be placed in an effective position in educational theory and for ecological concepts to become major criteria upon which policy and curriculum planning are based. The time has come for ecology to be recognized as the discipline that has been described as leading "from the classroom to ecosystems of great complexity, integrity, and fragility...[and] introduces us to some of the most complex aspects of reality "(George & McKinly, 1974; cited in Hale, 1987, p. 14). In short, ecology describes our true place in the natural ecosystem and our interaction with the components of the global environment and must be placed in the forefront of our knowledge system.

(2) Ecology should have its own distinct place in secondary science curriculum. Because of its deep-rooted social, economic, and political characteristics, ecological

problems and issues are more difficult than any of those of the natural sciences. There are no "...sciences available that can replace ecology" (Slobodkin, 1988, p.338). For this reason ecology is no longer a curious branch of biology studied by a small number of scientists. It has its own rightful place as a vital component in the educational process. If we accept ecology *only* as an integrative topic within other disciplines, we repeat the experience where geography was lost as part of secondary school education (See chapter one).

Ecological education should be mandatory in secondary school education. It must become as fundamental as the three R's for all students at the pre-college level. If the world's problems are in any way interconnected with human beings and the natural environment (and it seems evident that they are), then human understanding of ecology is essential in their solution. It is vital that members of the human society have a common ecological reference point; this can be achieved only through ecological education. An understanding of our complex ecological system is vital to human populations because it is vital that we learn how to be the stewards of nature, how to use the total environment responsibly, and how to live peacefully.

If developing the intellectual thinking capacity through which individuals are able to "possess a large armory of clear and specific concepts and to organize them coherently", is what is most required of schools (Barrow,1985, p.14), then schools should provide the kind of subjects and activities that link a wide range of knowledge. Ecology, by its nature, has the capacity to link the natural and social sciences and human beings to the natural world. Ecology can provide the educational background necessary for the development of a general thinking capacity that is necessary for individuals to see the world, "...more nearly as it really is now and to take sensible steps to improve it" (Barrow, 1985, p.17).

(3) School disciplines should integrate ecology related knowledge in their curriculum. The need for an active eco-education process in different professional sectors of society is also acute (Rosemarin, 1988). For example, if we are to make intelligent

decisions regarding the environment, improved environmentally based knowledge is needed in various areas such as environmental economics, health, medicine, law, alternative environmentally acceptable technology, and sustainable resource management and development. School disciplines as well should no longer be developed in isolation from the effort to resolve ecological problems; ecologization of other disciplines provides an additional pool of related knowledge and information which is essential if ecologists and educators are to make well informed and timely environmental decisions.

(4) Destructive forces and barriers to ecology education both inside and outside traditional learning institutions must be removed. The destructive forces of society[1], which drive its major institutions and determine the nation's impact upon nature, must be recognized and accommodated within ecocentric values when economic, social, and political decisions are made. It must also be understood that adopting an ecocentric philosophy imposes certain limits on human behaviour in various economic, social, and political activities (Marx,1974). Furthermore, other barriers such as lack of enough time, the necessary budget for teaching materials and equipment, flexibility in the school system, the existence of ecology in the core areas of the curriculum, lack of support from parents and the school administration must be recognized and dealt with intelligently. Without the removal of such barriers, we will not be able to teach ecology effectively and fulfill the purpose of ecological education.

(5) At this time the optional areas of Bio 11& 12 and related themes from Science and Technology 11 program should become mandatory topics to be taken side-by-side with Bio 11&12. To bring balance between the heavy reliance on biology and the little concern with relevance to societal problems and application in everyday life, the ecology and related themes in both the optional areas for Bio 11 & 12 and Science and Technology 11 program

[1]- The destructive powers of society are " the great business corporations, the military establishment, the universities, the scientific and technological elites, and the exhortation expansionary ethos by which we all live" (Marx,1974, p. 316).

must be integrated or be taken side-by-side-with Bio 11&12. The 1986 Bio 11 & 12 teaching materials are currently adequate for informing the students of what is essential. But like the science curricula of the 1960's which relied heavily on the structure of the disciplines with little concern for everyday life, it mainly provides the basic principles, concepts, facts and generalization of biology. This amounts to little more than a mastery of content with little concern for the relevance of that content to the societal problems.

At the level of ecology teacher education

(6) Design for teaching and learning ecology and environmental sciences should be a mandatory course in science teacher education. Ecology teacher education is essential for successful ecology teaching in the schools. Because the problem of effective ecology education lies in the teachers' abilities to teach ecology and related topics and not with those being taught, teacher education and teaching materials are critical. Ecology teachers should themselves learn about the true nature of ecology, the purpose of eco-education programs, teaching and learning in the field, lab, and classrooms, and should use combinations of many teaching strategies. Teacher education should also give teachers the appropriate opportunity to contribute their ideas to the syllabus, content, and methodology of ecology teaching (Uma, 1988).

(7) Teacher education should provide a clear conceptual understanding of what role biology and ecology teachers can play in concert with teachers of other disciplines in order to carry out an effective interdisciplinary strategy of teaching. This idea is not new. The 1970 convention of the National Education Association called for emphases such as this in environmental education, and many local and national environmental programs at that time were developed in the United States. Close cooperation of this sort will help teachers to overcome teaching boundaries traditionally created by discipline-dominated models of

teaching. (Of course, this could only work if the school policy, and the educational philosophy supports it.)

As well as instruction and workshops prepared by specialists in educational psychology, education, and science education, the Ministry of Education, school districts , and regional universities should all fund and carry out summer seminars and workshops for both school science teachers and university science instructors on the human social impact of science and technology on the environment.

Teacher education (specially inservice education) should also provide workshops for school and school district administrators about the special needs of the science and ecology oriented curriculum for example, for double periods, additional funds, yearly or bi-yearly inservice education, special materials and equipments, etc., Since school and school district administrators are in a decision-making position, then they are part of the problem because only few of them do really understand the special needs for such courses to be taught effectively (cf., Hufford, 1989).

At the level of teaching

(8) Teachers must concentrate more on field work. Observing and investigating living organisms in a simple accessible urban and natural ecosystem is necessary for developing an accurate understanding and appreciation of the environment and human's role in ecological processes and environmental management (Croft, 1986). Students must see the whole in their minds to understand the main function of the parts in relation to the whole. But the classroom is sometimes not suitable for teaching about whole ecosystems. Lisowski (1987) found that certain field instruction strategies have a positive influence on student understanding and retention of ecological concepts at the secondary school level. As Lisowski & Disinger (1988) pointed out "...field-based instruction is a teaching technique worthy of...implementation by practitioners and additional, intensified, rigorous

study by educational researchers" (p. 5). Other important strategies teachers should consider in teaching ecology are:

a) Using an involvement oriented model of teaching which emphasizes the total involvement of the learner and creates within him or her greater motivation and curiosity. In order to better achieve this, students must become involved in real-life situations. Here, teachers should use real environmental issues facing local communities. According to Bere (1986) when students get involved in regional issues and investigate real life situations in surrounding areas, "learning becomes meaningful, because it is needed by the students" (p. 432). He adds that:

> By examining their own surroundings in depth and then comparing their area to another, both teachers and students learn to understand relationships, develop historical perspectives, and begin to infer trends. They learn to use their own communities as microcosms of principles that remain valid at a global level. (p. 432-433)

Teachers should try to develop among students the mental tools that will help students identify problems and find creative solutions that are transferable from one situation to another.

b) Emphasizing and explaining the kind of difficulty students will face in their decision-making as environmentally concerned citizens in a technological society. Emphasizing that there is not always an easy solution or a "quick fix" to every ecological problem our society faces today. There is a limit to what science and technology can do. Awareness and understanding such as this will enhance students' ability to develop an appreciation for, and learn the value of, patience and persistence in thinking critically, acting intelligently and becoming sensitive to all the components of the ecosystem.

(9) Ecology teachers should use research projects in teaching about ecological topics and environmental issues. This teaching approach has been suggested because research projects enable students to be aware of the value of fundamental science, the

methods that researchers use to search for new knowledge, and solutions for a given problem. Thus, research projects will give them the scientific skills, techniques, and experience in searching for unsolved problems and practising moral judgment and decision-making. Research projects also enable students to integrate their acquired knowledge of different disciplines and to apply this knowledge to the resolution of specific questions or problems. Furthermore, students can be motivated by selecting local environmental problems and by feeling that the results of their projects might be considered important by local and federal government officials and the public

Ecology teachers should also consider the importance of nature in the moral and esthetic development of the individual. By developing children's feeling for the beauty of nature, teachers instill in the students "an aspiration to the natural environment in unity with moral and esthetic feelings" (Zverev, 1982, p.17).

At the level of educational institutions

(10) Educational institutions should recognize the growing importance of ecology for the coming decades and plan accordingly. If environmental disturbances (which are becoming quantitatively more significant) keep increasing, ecology education over the next two decades will be of great importance and intellectual benefit to the larger field of school disciplines. Educational institutions that fail to recognize this fact and fail to prepare themselves for such education, will lose the moral and financial support of government agencies and the general public as well as experience a sharp decline in student enrolment.

Education departments in the universities, for example, need a well formulated policy that will attract talented graduate students (from both basic and applied disciplines) to research interdisciplinary programs related to ecology and environmental sciences, education, philosophy, science, and technology. This is important because decisions on environment, science, and technology today have a greater impact on the world as a whole than almost any other decisions. Yet, education departments in high-tech societies do not offer graduate courses related to these issues. Graduate students of education need just as much understanding of environmental, scientific, and technological concepts and issues as they do of Plato, values, judgment and clarification, etc. If education faculties ignore these environmental issues they will produce educational policy planners and educators who do not understand the most basic fundamental problem facing western civilization.

At the level of educators, educational philosophers, and ecologists

(11) Educational philosophers, educators and ecologists must consider environmental problems and issues as educational issues. They should start to re-examine the role schools ought to be playing in developing the ecological consciousness necessary for survival into the 21st Century. Moreover, they should examine and evaluate their own contributions to eco-education and environmental issues. Educational philosophers, science and environmental educators, and ecologists should all take an active involvement in methods, curriculum development, and student attitudes and participation at the high school level. If these educators are to play a full role in the study of environmental problems, it is important that greater stress be given to ecology education as one of the main criteria for developing an educated mind, and to the biosphere as "...a vital resource base for man." Environmental problems are too important to be ignored. Using Slobodkin's (1988) expression, "if ecologists [as well as educators] do not take on these problems, the vast army of self-appointed experts are likely to do a much worse job" (p. 339). Perhaps scientists delay suggestions for action because of scientific uncertainty, and perhaps politicians use the same argument to postpone decisions regarding the environment and social issues. Thus, educational philosophers, ecologists and educators have to learn to take responsible decision-making positions on educational- environmental issues. It is their responsibility to cooperate with each other to communicate their knowledge and experience to other sectors of society.

<u>At the level of research</u>

(12) Since ecological principles and concepts form the cornerstone of eco-education, historical research and/or the historical perspective of eco-education or any of its components should be conducted and presented side-by-side with research in the history of ecology (as a science discipline).

(13) Different in depth approaches such as focus group interviews should be conducted with biology and ecology teachers about their teaching techniques and the difficulties they face in teaching ecology at different school levels. Furthermore, large-scale questionnaires should be conducted to obtain data in breadth to clarify the conclusions of this study regionally and nationally.

Final Remarks

This study reached the conclusion that the efficacy of teaching of ecology within biology education at the senior secondary school level has been ineffective in dealing with the human impact on regional and global environments, and in understanding human role in the ecological processes. While part of the problem lies in what we teach, how we organize it, and how we teach it to our students, the practice that arose from the 1986 curriculum reform which aimed to improve science education in British Columbia, deemphasized ecology and related topics in the core areas of science education. Furthermore, the problem goes even deeper, into the educational system whose policy makers and administrators influence curriculum developers, textbook publishers and science teachers to create programs that bore students with pointless instructional materials to be taught through lecture and 'cookbook' lab activities and worksheets. What should be developed are educational programs and teaching materials that help students to develop a commitment to life-long learning, to critical thinking, to self-understanding, to self-discipline, and to acting intelligently regarding the environment. If an ecologically sustainable society is to be achieved, moral and ethical values are crucial.

British Columbia biology teachers enthusiastically believe in the importance of ecology and environmental issues. They are also interested in helping their society to be ecologically better off by teaching about issues such as these. The pedagogical answer for productive ecology education in British Columbia public schools comes through (1) ecology becoming mandatory in science curriculum, (2) educating teachers in the content and methods required by the new courses in ecology and environmental sciences, and (3) modifying the school system to be more suitable for ecology education and other interdisciplinary curriculum. The first step in achieving this new approach to biology and ecology education takes place outside the classroom in "education's true workplace - the minds of its decision and policy makers" (Rhodes,1988, p. 28). Those professionals must understand that the purpose of education is to develop the rational thought necessary to understand the environment, and the intelligent action necessary for better interaction with the components of the environment of which we are a part.

Undoubtedly, ecology will play an important role in any future society. To ignore it now, will be to promote a future mass human suicide.

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Appendix 2.1

What Is Ecology ?

Ecology is an integrated scientific area of study concerned with the interrelationships between living organisms and their environments. The concern of ecology is not only to study, but also to preserve such interrelationships in their optimum state of natural equilibrium. This therefore, makes ecology more than just a normal scientific discipline. It is like a description of a philosophical perspective and in a sense a social and political position (Sale, 1986; Ophuls, 1977). Or, as Odum (1975) puts it, is the integrated science that links together the biological, physical and social sciences.
Most people know that relationships between organisms and their environments occur everywhere on the earth, but most people do not know enough about (1) the working systems of these ecological relationships and interdependence, (2) the external and internal sustaining factors responsible for the harmony of the ecosystems,(3) the ecological implications of human activities on the interactions and interdependence within a giving ecosystem, (4) how to develop the skills necessary for choosing, evaluating, and taking appropriate environmental action, (5) how to look after this earth and the life on it whether as individuals and as groups, and most of all (6) they do not fully understand how precisely society and nature interrelate. In spite of the conclusions of many reports that the world in the year 2000 will be "more crowded, more polluted, less stable ecologically, and more vulnerable to disruptions than the world we live in now" (Barney,1980,p.1; cited in Bybee & Najafi,1986,p.443), only a few schools have a planned program aimed at developing ecological awareness and understanding among all its pupils and little that might serve to alleviate these problems is being taught or learned in the schools. Here, the need for ecology education is laid. The rationale for an ecological education is to improve students' interest in an appreciation of ecology, and to develop an accurate understanding about the behavior of ecological systems and the impact of human behavior on those systems. After all, ecology is not only interested in the relationship between organisms and their environment, as well as the delicate balance of ecosystems, but it is also "interested in man's role in the environment, his technology, his wars, and his thinking" (Mckenna, 1971, p. 294).

Appendix 4.1

Given the purpose of the thesis and the aims of the groups of research questions the following questions were posed in teacher interviews:

I Research Questions, Group One (Personal Awareness):

1- Is there an ecological crisis, and if so, how serious is it?
2- What will it take to awaken an environmental consciousness toward a more sustainable society from the biology teacher's perspective?
3- What is the need for education today regarding world ecology? How well are schools equipped to educate people regarding environmental issues/problems?
4- How comprehensive is the treatment of science and society in high school biology textbooks in terms of controversial aspects, questions of ethics and values, global perspective, and the interdisciplinary nature of the problem?

II Research Questions, Group Two (Ecology Educational Goals):

1- Do you teach ecology topics in your biology classes? If so, how do you rate the importance of teaching ecology in comparison with the other biology topics ?
2- What is the goal of ecology education?
3- What are the aims and objectives of teaching ecology at the secondary school level today?
4- What should the aims and objectives be of teaching ecology at the secondary school level? (A list of aims and objectives for science teaching in senior high school identified by the Science Council of Canada(1983) was given to the surveyed in both question 3&4 to examine.

III Research Questions, Group Three (Ecology Educational Content):

1- What would you like your students to understand ecologically before they graduate from secondary school?
2- Which ecological concepts are being taught in biology classes of secondary school?
3- To what extent do you use various instructional resource materials to teach ecology?
4- What is the main educational resource in your present ecology teaching ?
5- To what extent do you use the textbook in your ecology teaching?
6- Do ecological questions get direct or indirect emphasis on both provincial and your evaluation exams?
7- How do you evaluate the ecology section of your general biology textbooks?

IV Research Questions, Group Four (Ecology Educational Instruction):

1- How do you usually teach ecological topics?
2- To what extent do you use various instructional methods to teach ecology ?
3- Which of these various teaching models are close to your present ecology teaching style? (List of teaching models adopted by Jones, Thompson, and Millier (1980) from Joyce and Wiell's (1980) four families of teaching models was given in both questions, 3&4.)
4- Which of these various teaching models would you like to use if you had the opportunity?
5- Which of these reasons prevents you from teaching ecology effectively and why? (List of reasons identified from related literature (particularly Booth, 1979) was given here)

V Research Questions, Group Five (General Related Questions):

1- Is there any in-service education regarding ecology teaching based on your knowledge? If so, how effective was it? And how many did you attend?
2- If you had the opportunity to attend an in-service ecology education course, would you like to ? How many hours do you think per year would be useful for teachers to gain and maintain effectiveness in teaching ecology?
3- What kinds of advice would you give secondary school teachers who have to teach ecology at the secondary school level?
4- What kind of role should industry play in school education regarding ecology?

Appendix 4.2 a

Appendices 4.2a and 4.2b show examples of how key words and phrases in the data were highlighted and themes identified which were later used to classify the data for final analysis and interpretation.

1- Group one of research questions (Personal Awareness):

1. Is there an ecological crisis on the earth, and if so how serious is it?

Teacher = 1	Agree, *multiplying*, **educated people aware**, may be no action.
Teacher = 2	Agree, *multiplying*, **awareness declining** from the 1970's.
Teacher = 3	Agree, *multiplying*, caused by industry, we know more about it.
Teacher = 4	Agree, *multiplying*, caused by industry & **people and society attitudes, people unaware, schools don't cover that much**
Teacher = 5	Agree, **unsure of multiplying**, compound caused.
Teacher = 6	**Neutral.**
Teacher = 7	Agree, incredibley *serious*, we have not done a good job of taking care of the earth.
Teacher# 8	Agree, *multiplying*, there is enough evidence, but nothing seem to be done. **People are moving farther away from being close to nature; the attitude which arose in the 1960's.**
Teacher# 9	agree, *serious*, the longer I teach, the more important I believe it is.
Teacher#10	Agree, **but it may not be as serious as 20 years ago.**
Teacher#11	Agree, it is important to **make students aware of them.**
Teacher#12	Agree, *serious* enough to look at in terms of 50-100 years.
Teacher#13	Agree, *serious*. Think about acid rain, **scientists have been talking about it for years,** but politicians wish the problem did not exist. There is also belief among some politicians that the problem is minor, we can live with it, or it will cost a lot to do something about it.
Teacher#14	Agree, *serious* for health, **people become increasingly aware** of it through the risk of health.
Teacher#15	**Neutral.**
Teacher#16	Absolutely without any shadow of a doubt, *very serious*, **making students aware is one of the jobs of biology teachers.**
Teacher#17	Definitely. **There is a change in the kids within the last five years towards** "why should I worry about these things if I am the only one to sacrifice, it is not my problem" **"Very Me" generation.**
Teacher18	Yes, *a very acute and serious one. It is going to be more serious* before we could rectify it should we choose to. **The Law of Nature applies to all and we have chosen to go against that in many respects.** We don't have the facts to know what we've done, but surely we've done something
Teacher#19	Agree, *serious* crisis, *multiplying*. **The solution must come from politicians not from biology teachers.**
Teacher#20	Agree, *serious*, **population is increasing and so is the ecological crises.**

Appendix 4.2b

2. What will it take to awaken an environmental consciousness toward a more sustainable society from the biology teacher's perspective?

Teacher# 1	A few **catastrophes** - something that actually has an impact on a large part of the population.
Teacher# 2	**Disaster** - but the difficulty is the scale of it which might be irreversible.
Teacher# 3	*Neutral.*
Teacher# 4	*Neutral.*
Teacher#.5	**Education** - introducing ecological principles in all levels of science. The Chernoble **disaster** gave us time to think & to reflect that we are part of this global village.
Teacher# 6	**Education** - especially through the tremendous explosion in adult education. Kids & parents might discuss these issues at the dinner table.
Teacher# 7	**Curriculum** - but government and its divisions are not able to see the ecological side of it. There is no ecological core in the new biology 11.
Teacher# 8	**Crises** - maybe if millions of people died around us. *Radical changes in the way we live*. **People don't** know what hit them; they don't have **any idea of science, ecology**, etc.; they feel helpless.
Teacher# 9	**Education** - we need to educate people, media is effective to a degree, but I think the most effective way is to educate students.
Teacher#10	*Neutral.*
Teacher#11	Students who get enough biology will have the opportunity to develop a social consciousness toward the environment. Because there is an awareness placed in front of the students "that all is not well", "that there are problems and there are alternatives"**I believe we are having an impact on them through education.**
Teacher#12	Political decision - environmental consciousness toward a more sustainable society is there but not at the political decision making level.
Teacher#13	**Disaster** - *but every geographical area has to have its own version of the disaster before it is seen as a* problem that must be solved . Human respense to crisis is very quick; when any crisis finally becomes a public issue, then things will change.
Teacher#14	**Education** - but it might need more than just education.
Teacher#15	**Crisis,** but also we need to educate the public through **formal and informal education.**
Teacher#16	**Major catastrophes.** Teaching is not going to do it; it is going to make people aware of what to do when the crisis comes if they can do anything. But it is going to
Teacher#17	**Probably crisis.** The threat of not having something or not being able to use something is the only thing that is going to shake up most of the kids right now. Kids have the attitude that only if it bothers me I will deal with it.
Teacher#18	**Education and facts.** If people know what the problem is and the price that will be paid, then they will mobolize and do something about it.
Teacher#19	It has to be done politically, but when the dollar is involved, I can't see the government taking this kind of base to solve ecological problems.
Teacher#20	Political, but they (politicans) are always concerned with the next election.

Organizational Chart
Biology 11

BIOLOGICAL LEVELS		CONTENT AREAS	TEXT REFERENCES		SUGGESTED LAB EXCERCISES	SUGGESTED TIME IN HO[URS]
BIOME COMMUNITY POPULATION	BIOLOGY 11	ECOLOGY	BSCS YELLOW VERSION- "BIOLOGICAL SCIENCE, AN INQUIRY INTO LIFE" - FIRST EDITION CHAPTER 8. THE BALANCE OF NATURE 39. THE LIVING WORLD 40. MAN AND THE BALANCE OF NATURE	BSCS GREEN VERSION- BIOLOGICAL SCIENCE: AN ECOLOGICAL APPROACH - THIRD EDITION CHAPTER 1. THE WEB OF LIFE 2. INDIVIDUALS AND POPULATIONS 3. COMMUNITIES AND ECOSYSTEMS 7. LIFE IN THE MICROSCOPIC WORLD 8. LIFE ON LAND 9. LIFE IN THE WATER 10. LIFE IN THE PAST 20. MAN IN THE WEB OF LIFE	Student Laboratory Outline 3, 4 5, 6 7, 8	30
		DIVERSITY	9. VIRUSES 10. BACTERIA - PIONEERS OF CELLULAR ORGANIZATION 11. SMALL ORGANISMS OF GREAT ECONOMIC IMPORTANCE 12. MOLDS, YEASTS AND MUSHROOMS 13. THE TREND TOWARD COMPLEXITY 14. THE LAND TURNS GREEN 18. THE WORLD OF ANIMALS 20. THE DIVERSITY AMONG ANIMALS-VARIATIONS ON A TV	6. PROTISTS 5. PLANTS 4. ANIMALS	9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26	40
ORGANIS.		EVOLUTION	34. DARWINIAN EVOLUTION 35. THE MECHANISMS OF EVOLUTION 37. THE EVOLUTION OF MAN 38. THE CULTURAL EVOLUTION OF MAN 41. A PERSPECTIVE OF BIOLOGY	18. EVOLUTION 19. A BIOLOGICAL VIEW OF MAN	27	

Appendix 6.1

The 1974 Biology 11 organizational chart in secondary public schools of British Columbia Canada.

Appendix 6.2

Organizational Chart

Biology 12

			TEXT: FOUNDATIONS OF BIOLOGY	Investigations of Cells and Organisms	
ORGANISM ORGAN AND TISSUE	BIOLOGY 12	PHYSIOLOGY	CHAPTER 31. The Green Plant Cell 32. Plant Nutrition 33. How Plants Grow 34. Development of the Plant Body 36. Survival and The Internal Environment 37. Transport 38. Motion 39. Information Transfer 40. Circulation 41. Blood 42. Oxygen 43. Salt & Water - The Kidney 44. Food 45. Metabolism & Hormones 46. Interpreting the Environment - the Brain 47. Reproduction	20, 21, 23, 31, 38, 39, 42, 43, 44, 47, 48(B), 49 33, 35, 36, 37 Fetal Pig Labs 633 - 639	55
CELL MOLECULE		CELLULAR BIOLOGY	8. The Cell 9. General Cell Features 11. The Nucleus - Control Centre of the Cell 13. The Chemistry of Biological Compounds 14. Major Compounds of Cells 15. Metabolic Properties of Cells 16. Metabolism & Energy 17. Light and Life 18. DNA - The Molecule of Life 19. Control of Cellular Metabolism *12. Atoms & Molecules	12, 13, 14, 15, 16, 17, 18, 24, 25, 26, 28, 29	15
		EVOLUTION	3. Adaptation: How Organisms Respond to Their Environment 27. The Evolution of Inherited Patterns 28. Causes and Results of Evolution *10. Cell Division *20. Inheritance of a Trait *21. Meiosis and its Relation to Sexual Reproduction *29. The Origins of Man		10

* If students are not familiar with the contents of a chapter marked with an asterisk (*), then this chapter should be considered to be a text reference.

Appendix 6.2

The 1974 Biology 12 organizational chart in secondary public schools of British Columbia, Canada

BIOLOGY 11 OVERVIEW

OPTIONS

I. MICROSCOPY — 5 hrs.

II. MYCOLOGY — 5 hrs.

III. BRYOPHYTES/FERNS — 5 hrs.

IV. INVERTEBRATES — 25 hrs.

V. PARASITOLOGY — 10 hrs.

VI. VERTEBRATES — 25 hrs.

VII. FISHERIES BIOLOGY — 10 hrs.

VIII. WILDLIFE BIOLOGY — 10 hrs.

IX. FRESHWATER BIOLOGY — 10 hrs.

X. POPULATION & COMMUNITY ECOLOGY — 10 hrs.

CORE 70 HOURS

METHODS & PRINCIPLES 15–20 HOURS

I. The Realm of Biology
II. Scientific Method
III. Levels of Organization
IV. Adaptation & Evolution
V. Classification & Taxonomy

MICROBIOLOGY 15–20 HOURS

VI. Overview of Microbiology
VII. Viruses
VIII. Monera
IX. Protists

PLANT BIOLOGY 15–20 HOURS

X. Overview of Plant Biology
XI. Green Algae
XII. Gymnosperms
XIII. Angiosperms

ANIMAL BIOLOGY 15–20 HOURS

XIV. Overview of Animal Biology
XV. Insects
XVI. Mammals

OPTIONS

XI. ANIMAL BEHAVIOUR — 5 hrs.

XII. EVOLUTION & THE FOSSIL RECORD — 5 hrs.

XIII. GENETICS — 10 hrs.

XIV. SILVICULTURE — 5 hrs.

XV. BIOETHICS — 5 hrs.

XVI. CAREERS IN BIOLOGY — 5 hrs.

XVII. POPULATION GENETICS — 5 hrs.

XVIII. TERRESTRIAL HABITATS — 5 hrs.

XIX. INTERTIDAL MARINE BIOLOGY — 10 hrs.

XX. AQUACULTURE — 5 hrs.

Appendix 6.3

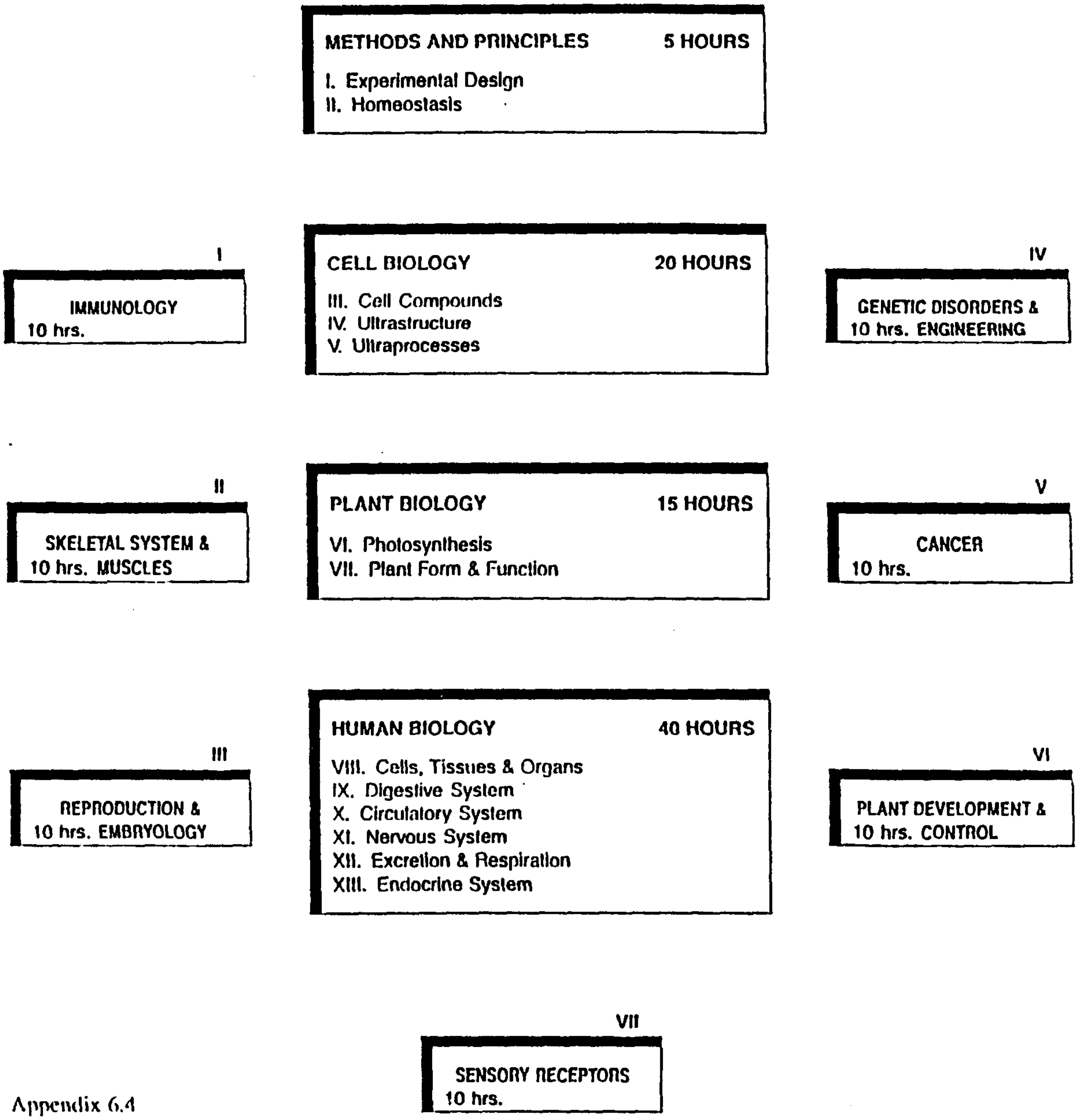
The 1986 Biology 11 organizational chart in secondary public schools of British Columbia Canada.

Province of British Columbia
Ministry of Education
CURRICULUM DEVELOPMENT BRANCH

Appendix 6.4

BIOLOGY 12 OVERVIEW

CORE 80 HOURS



Appendix 6.4

The 1986 Biology 12 organizational chart in secondary public schools of British Columbia Canada.

Province of British Columbia
Ministry of Education
CURRICULUM DEVELOPMENT BRANCH

Appendix 6.5

The question cues in the 1986 Biology 11 & 12 Learning outcomes Based upon the use of abloom's cognitive taxonomy, the most of the core and optional learning outcomes are written at the knowledge and comprehensive levelsof performance objectives.

	Core Areas		Optional Areas	
Word or Question Cues	Bio. 11	Bio. 12	Bio. 11	Bio. 12
Calculate			1	
Analyze			1	
Apply			1	
Assess			1	
Categorize			1	
Cite the evidence used to			1	
Classify			2	1
Compare	**8**	**8**	**18**	**5**
Complete		1		
Conduct				
Contrast	**10**	**9**	**18**	**4**
Construct	2		2	
Criticize			5	
Deduce		1		
Defend			4	
Define	**12**	**11**	**16**	**9**
Demonstrate	3		5	
Describe	**45**	**43**	**90**	**26**
Discriminate		1	1	
Design		1		
Determine	1	1	1	
Diagram	3	2	2	1
Differentiate	5	10	2	3
Discuss	3	4	11	4
Distinguish		8	9	8
Draw		3	1	
Estimate			1	
Evaluate	1		4	
Explain	**12**	**23**	**22**	**14**
Formulate	2		1	
Give	8	7	8	2
Graph			1	
Identify	**14**	**21**	**31**	**6**
Indicate	1	5	6	2
Interpret			1	
Investigate			1	
Label	3	2	1	3
List	**11**	**13**	**7**	**6**
Locate		1		1
Name	1	3	1	
Outline	**10**	**10**	**20**	**12**
Point out			1	
Postulate	1		1	
Predict		1	2	1
Propose			4	2
Provide		1		
Recognize	1	2	1	
Relate	2	13	6	4
Show			1	
State	1	12	3	3
Solve			1	
Suggest	2	2	16	2
Summarize		2		
Support		1		
Trace or follow the path		1	1	1
Use	1			

Appendix 6.6

The question cues in the study questions of the two main biology textbooks *Inquiry Into Life (1985) and Macmillan Biology* (1985) being used in B.C. biology 11 & 12 classroms. Based upon the use of abloom's cognitive taxonomy, most of the study questions are written at the knowledge and comprehensive levelsof performance objectives.

Question Cues	Macmillan Biology (1985)	Inquiry Into Life(1985)
Answer	1	
Arrange In...		1
Ask	2	
Build model	1	
Calculate	7	3
Can/Could you...	3	1
Carry out	1	
Cite the evidence	2	1
Compare	10	16
Complete the idea	189	
Copy (match) the number	235	
Construct	1	
Contrust	7	7
Convert the following	1	
Debate	1	
Deduce		
Defend		
Define	60	19
Demonstrate	2	
Describe	154	77
Design	4	
Determine	7	
Devise	4	
Diagram/make digram to...	8	
Differentiate	9	1
Discriminate		
Discuss	5	44
Distinguish	22	2
Draw/ Draw conclusion	6	17
Does/Do	8	
Estimate		
Evaluate	1	
Explain	89	29
Examine	1	
Express		
Fill		1
Find out/how	1	
Formulate		
Give	38	54
Graph	1	
How	151	47

Appendix 6.6

The question cues in the study questions of the two main biology textbooks *Inquiry Into Life (1985) and Macmillan Biology* (1985) being used in B.C. biology 11 & 12 classroms. Based upon the use of abloom's cognitive taxonomy, most of the study questions are written at the knowledge and comprehensive levelsof performance objectives.

Has	1	
Identify	4	1
Illustrate	1	
Indicate	2	4
Inquire	1	
Interpret		
Investigate		
Is/Are/Were	7	1
Lable		1
List	39	9
Locate		
Make prediction/ make to show	18	
Name	22	55
Obtain	1	
Outline	5	3
Plan how	1	
Point out	2	
Postulate		
Predict		
Propose		
Provide		
Recognize		
Recorde	3	
Relate	1	5
Research	6	
Show		2
Sketch	2	
State	15	9
Solve		
Suggest	1	
Summarize	4	
Support		2
Tell how	3	5
Trace or follow the path	9	9
Use/use to write	3	
What/in what/ ofwhat/ to what	311	144
When		4
Where	2	5
Which/in which	11	17
Why/ Why not	47	18
Would	2	1
Write to show	3	
Write (match) the correct #	235	

Appendix 7.1

The following samples of mathematical problems are proposed by Schwartz (1986) to illustrate how environmental issues are used as themes for teaching mathematical skills. They have been cited here to be used in teaching ecology in order to enhance students' understanding of some ecological concepts and principles. According to Schwartz (1986), in each following problem, " students are encouraged to not only get a numerical answer, but to consider the significance of the answer with regard to environmental problems such as, pollution, resource, scarcity, rapid population growth, and waste" (p. 32) However, for students to do this, they should be able to calculate, to reason quantitatively, to clarify issues, and to support or refute opinions (Frankenstein, 1983) and decisions in regard to the environmental implications of events at the local, national, and global level.

1. At current growth rates, it will take 20 years for Nicaragua's population to double. At this rate, how many people will there be in Nicaragua in a century, for every one there today?
2. It has been estimated that the average American has fifty times the impact on the environment (in terms of resource consumption and pollution) as does a person in a less developed country, such as India, Nigeria or Honduras. How many people in these countries have the same environmental impact as 235 million Americans (the approximate U.S. population in 1983)?
3. Draw a circle diagram for the population of the world's major regions, using the following data for 1983:

Region	Population (millions of people)
Africa	513
Asia	2,730
North America	259
Latin America	390
Europe	489
USSR	272
Oceania (Australia, New Zealand, and nearby islands)	24

4. The average annual age-adjusted respiratory cancer deaths (per 100,000 population) is given below for the five boroughs of New York City for the 1974-1976 period:

Staten Island	38.7	Brooklyn	30.0
Manhattan	30.0	Queens	28.1
Bronx	27.6		

a) Compute the percents by which the Staten Island respiratory cancer deaths exceed those of each of the other boroughs.

b) Compute the ratios of the Staten Island respiratory cancer deaths to those of each of the other boroughs.

5. The average American uses 60 gallons of water per day in the home. About 24 gallons of this water is used for flushing toilets. Each toilet flushing uses about 6 gallons of water. If you placed a brick whose dimensions are 2 inches by 4 inches by 8 inches in the toilet storage tank, how many gallons of water would you save in an average week? One gallon equals 231 cubic inches.
6. Because of pollution, the natural life of Lake Erie was cut by about 15,000 years in approximately a half century. Calculate the average number of years cut off its natural life in just one year.
7. It takes about 17 trees to produce one ton of paper. How many trees would have to be cut down to produce the 14 million pounds of paper used by the *New York Times* and the *New York Daily News* on an average Sunday?
8. Plot a graph using the data below for the total production of electrical energy for various years.

Year	Electrical energy (trillion kilowatt hours)
1902	6
1912	25
1920	57
1930	114
1940	180
1950	389
1960	844
1970	1640
1975	2003
1977	2211