

# **Nurturing Scientific and Technological Literacy through Environmental Education**

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## **Abstract**

Achieving scientific and technological literacy (STL) for all remains to be a universal goal for science education and an important challenge to many countries. The suggested innovation is to “green the curriculum” that is, integrate environmental education (EE) objectives, concepts and skills into science and other subject areas. Studies indicate that attitude towards the environment and attitude toward science do influence each other. Pupils in schools with active environmental programs have been found to possess skills needed to form judgments of their own environmental issues, especially in the face of contradictory media messages about the environment. EE helps students “learn how to learn” as they engage in real-life problem solving and decision-making. The motivation for EE is not just to make teaching and learning relevant and interesting but also to help students to recognize their role in addressing environmental degradation, the most serious problem facing humanity today. EE integration in the curriculum is going on in many countries but good practice is not widespread. Training programs and instructional materials must highlight the value-laden environmental core messages and the need for more cooperation at the local, national and international levels.

## **Introduction**

Developing “literacy” is a focal point in problematizing science and mathematics education reforms. In other words, it is imperative for science and mathematics educators and scholars to find more innovative ways of helping students understand and employ languages and ideas of science and mathematics in reasoning, communicating and solving problems. Scientific literacy stresses the development of habits of mind to facilitate individual and group problem solving (American Association for the Advancement of Science 1990). On the other hand, mathematical literacy means developing students’ abilities to explore, conjecture, and reason logically as well as the use of a variety of mathematical methods effectively to solve real life problems.

This paper deals with creating learning environments that nurtures scientific literacy. Science educators argue that scientific literacy is closely linked with technological literacy. Thus, the goal of science education is “scientific and technological literacy for all” (UNESCO 1993).

What makes an individual scientifically and technologically literate? He or she is one

who is aware that science and technology are human enterprises with strengths and limitations, understands key concepts and principles of science, is familiar with the natural world and recognizes both its diversity and unity, and applies scientific knowledge for individual and societal purposes (AAAS 1990). Years before, Miller (in Solomon & Aikenhead 1994) made a distinction between “educated” people who possess knowledge and “literate” people who can read about, comprehend, and express opinions on scientific matters. Solomon & Aikenhead (1994) added that to express an opinion, a minimal level of scientific knowledge is thought to be required supported by a positive attitude towards science.

### **Current Efforts In STL Enhancement**

There are many organizations that promote STL in different parts of the world. In the US, there is an International Center for the Advancement of Scientific Literacy. The American Association for the Advancement of Science has published *Science For All Americans* and *Benchmark for Scientific Literacy*. The National Science Foundation publishes annually reports on science and technology indicators. The European Commission has published survey data comparing the public understanding of science. The International Council for Comparative Study of the Public Understanding of Science and Technology has been conducting international conferences on the same topic (Sjoberg 1996).

Most, if not all, schools have adapted the Science-Technology-Society approach to teaching to help students find meaning and relevance of what they learn in school with activities in the real world. Issue-based topics like the green revolution, energy alternatives, genetic engineering, space travel, medical advances and even euthanasia are introduced into the school curriculum. While analyzing the issues, students are expected to learn about science and technology concepts and acquire problem-solving and decision-making skills.

In the Philippines, JICA funded a five-year program to promote the Practical Work approach in science and mathematics education. The same project is being implemented in Kenya and South African countries (Nagao 2001).

UNESCO, through the International Council of Associations for Science Education (ICASE) has been aggressive in promoting STL through Project 2000+ across the world. The Director General emphasized the importance of STL during the project launching. He said that “in a world that is increasingly shaped by science and technology, people need basic science knowledge and skills if they are not to be alienated in some degree from the society in which they live, if they are not to be overwhelmed and demoralized by change, if they have to make those multifarious political, environmental and ethical choices in which scientific discovery and its consequences are confronting us all”. In other words, the ability of citizens to use science and technology concepts in solving daily life problems and utilize skills to meet basic needs, prevent and avoid disasters, increase productivity, and alleviate poverty are manifestations of a scientifically and technologically literate person.

The list of organizations and activities is long. It seems however, that current initiatives are inadequate.

## **STL for All Remains a Universal Goal and a Challenge to Many Countries**

Reports from different countries reveal that students' motivation in the sciences has decreased as evidenced by the reduction in enrolment and apparent attrition in academic achievement. Science education in many countries is characterized by its appeal to the more able students. This leads to the impression that science subjects are difficult compared with other subjects because it (often) consist of very abstract ideas which demand intellectual thinking and are necessary for science careers only (ICASE et al. 2001). Science, therefore, is perceived as irrelevant in attending to the needs of the individual and society.

The National Assessment of Educational Progress Report (NAEP 1996) showed that although most US students have some grasp of basic scientific facts and principles by the end of high school, they were not able to apply scientific knowledge to a new situation, design an original experiment, or explain the reason behind their answers. Students from developing countries performed poorly in the Third International Mathematics and Science Study conducted in 1999. In Japan, there are many students who are not scientifically literate and have a negative attitude toward science. The study of Suzuki et al. (1996) inquired into how the phenomenon "Rika-girai" or negative view of science among students affected scientific literacy.

A study on the self-assessed level of knowledge about science and technology and other issues reveal that Americans do not believe they are well informed about issues in science and technology (NSF 1999). The European Commission published survey data comparing results from European countries in 1993 and a major finding was that many people have misconceptions about basic science and technology concepts (Sjoberg 1996). Business and industry representatives complain about the lack of employability skills of young people that include reading, basic arithmetic, problem solving and decision making, dependability, cooperativeness and other affective traits (Cotton 1997).

An incident in the Philippines is an example of the public's low level of scientific and technological literacy. In October 2000, an outbreak of a flu-like disease in at least five private schools in Metro Manila resulted in the suspension of classes. Children affected were reportedly experiencing nausea, severe headache, persistent coughing, fever and cold. Reports said that about 400 children were affected in these schools although victims may have reached a thousand (Manila Bulletin 2001). Speculations were that the epidemic maybe a biological weapon unleashed by terrorists to strike fear in the heart of the city's elite districts. The news about the epidemic spread very fast as it was reported through television and radio and passed on to friends and family through text messaging. The school administrators, teachers, parents and children panicked because of the media report. The Department of Health and the Department of Education investigated and concluded that the influenza or flu epidemic was caused by the changing weather condition. Some blamed environmental pollution as a contributory factor to the low resistance of students to the disease. To control the spread of the virus, schools were required to fumigate their surroundings and to clean air conditioning units. These actions put a stop to the epidemic

and the sensationalized reporting.

Many people fall prey to outright media reports because they do not analyze the situation before responding. People accept as truth what they hear because of their inability to conduct further investigation. The incident highlights the need for people to acquire knowledge and skills of basic science and technology concepts and learn how to ask the right questions and evaluate the quality of answers to prevent similar alarming situations. For example, questions could have been asked to clarify the situation: What causes the outbreak of biological or chemical weapons? If an epidemic was caused by biological and chemical warfare, then why is it that only elementary school children were severely affected? Or, in other circumstances, why is it that only children from private schools succumb to an epidemic in spite of the presence of children from public schools around the area?

In many countries, the low level of scientific and technological literacy is also shown in situations where people are dying from diarrhea when they only need to practice simple sanitation and maintain a clean environment. In other cases, children are malnourished even if their parents are financially capable because they are not eating the right kind of food. People continue to throw mixed wastes in bodies of water because they do not see that these are carried to other places and could be converted into toxic forms. Many countries have difficulty implementing the solid waste segregation scheme because people do not appreciate the value of proper waste management on their lives. People still believe in horoscopes and fortune telling rather than getting scientific explanations of events.

There are several reasons for the sharp decrease in the interest of students in science, or their dismal performance in national and international tests as well as their lack of non-technical skills to find and hold on to a good job. These situations reflect the concern regarding the serious gap between science education as it is practiced and the science education knowledge and skills (scientific and technological literacy) needed for day-to-day living. It means that our educational system is not providing students with the kind of quality experiences needed in a world increasingly shaped by science and technology. The schools are not developing the range of attributes needed to use and solve problems, or face issues that could be responded by science and technology learning. Our schools are not producing informed citizenry capable of making intelligent decisions and taking personal actions as a result of these decisions (ICASE et al. 2001).

The challenge is to make science education more relevant and interesting, not just for the science inclined and bright students but for the greater numbers. The challenge is to promote STL, not only in schools but also in the larger global community.

### **Changing Attitude Toward Science and Achievement in Science Through Environmental Education**

In a seminar on breakthroughs in science where I participated in as a resource person some years ago, high school students were asked before the session about the topics they were interested in. In their responses, genetic engineering, transportation and communication

technology including space travel were mentioned but most were interested in science and technology applications to agriculture, health, environment and natural disasters, especially prevention and mitigation of problems and/or earning a living. During the question and answer session, the students were asked about their position on some science and technology-related issues and one said she learned genetics in school but believed it was difficult to rationalize the choice of a boyfriend or marriage partner because of emotional considerations. Other students said they enjoy watching science fiction movies but these situations are products of human imagination and cannot happen in real life. Moreover, the overcrowded science curriculum makes it impossible for them to learn in-depth the knowledge and skills needed to cope with daily life problems.

These are examples of simplistic arguments about the kind of STS topics that students want to learn but they serve as wakeup call for teachers, curriculum developers and policy makers. The students' answers and studies on educational psychology tell us that one of the motivating factors is interest in the topic and such interest depends largely on the applicability to their daily life.

Further research indicates that attitude towards science and achievements in science contain a positive relationship (Schibeci 1984 in Xin & Bateson 1999) while certain instructional and behavioral interventions can change attitude toward science (Mason 1983; Mason & Kahle 1989). Other studies reveal that students who had a favorable attitude toward the environment also showed a favorable attitude toward science especially if these interventions involve student participation. This relationship indicates that attitude towards the environment and attitude toward science do influence each other (Xin & Bateson 1999).

Wilson (in ERIC Digests 1996) suggests that EE should be started early in a child's life because "nature-related experiences tend to foster a child's emerging sense of wonder referred to by Plato as "source of knowledge" and by Cobb as a "source of imagination". Positive interaction is an important part of a healthy development and such interaction enhances the learning and quality of life over one's lifetime.

Therefore, much can be learned on how to develop successful STS lessons, modules and courses by analyzing a related program, the Environmental Education (EE) program. The motivation for EE is not just to make teaching and learning relevant and interesting but helps students to recognize their role in addressing environmental degradation, the most serious problem facing humanity today.

## **Science, Technology and Environment Interaction**

Many reports have been written about the relationship between science and technology and the state of the environment. Theodore Roszak, an American philosopher, argued that science studies emerged "from the rape of the environment" (Solomon & Aikenhead 1994, p.v). It is reasonable therefore, that environmental problems are discussed in schools mainly from the natural science perspective. The social dimension of the problems has been highlighted in *Silent Spring* by Rachel Carson in 1962 which awakened the public attention

to the “quiet slaughter of birds and butterflies due to new technologies” and *Limits to Growth* by the Club of Rome which gave rise to many debates on the effects of exponential growth on fuel use, the finiteness of fuel resources, world population explosion and limited food production. In *Saving Our Planet*, UNEP Director Tolba presented many positive changes that happened in the environment since the UNCED Conference in Rio de Janeiro in 1992 but he also emphasized that many negative aspects still need to be addressed.

The Asian Environmental Outlook Report (ADB 2001) underscored that because of environmental degradation, people’s health and livelihoods, the survival of species and ecosystem services that are the basis for long-term economic development are at risk. It also mentions that Asia will find it difficult to achieve long-term sustainable economic growth unless countries in the region pay attention to solving the enormous environmental problems. The Global Environment Outlook Report (UNEP 2000) blames the intense poverty of marginalized groups and excessive consumption by a few as two major causes of environmental degradation. When CNN interviewed an ADB environment expert about the environmental situation, he supported the UNEP and UNESCO reports that indeed there is “inadequate awareness of Asian people regarding the environmental problems in the region.” In our own countries, we are witness to the pervasive, accelerating and unabated deterioration of the environment.

Many countries have started addressing this concern by greening their curriculum, that is, integrating EE into the formal curriculum of classroom learning and the organizational and operating procedures of the school through its environmental management (or its informal curriculum). EE is based on the 1977 Tbilisi Doctrine, though suggestions have been made to focus the current efforts towards Education for Environment and Sustainable Development or ESD (Thessaloniki Declaration, 1997). The goals of EE or ESD are the same - to develop a great majority of children and adults with a sense of responsibility to care for, protect, and enhance environmental quality that is conducive to their well being and supportive of their nations’ economic development. One environmental educator said “EE is like a diamond which appears to be of different color when seen from different angles”.

The informal education aspect is important because studies show that students in a school with active environmental programs are more likely to have the skills needed to form judgments of their own environmental issues especially in the face of contradictory media messages about the environment

## **The Nature of EE**

Because of the multidisciplinary and interdisciplinary nature of EE, it is often difficult to define. The North American Association for Environmental Education however, describes EE as the following:

EE is good education. It is learner-centered, providing students with opportunities to construct their own understanding through hands-on and minds-on (my addition, ‘hearts-on’) investigations. Learners are engaged in direct experiences and are challenged to

use higher-order thinking skills. EE supports the development of an active learning community where learners' share ideas and expertise and prompt continued inquiry. EE provides real world context and issue from which concepts and skills can be learned. EE recognizes the importance of viewing the environment within the context of human influences, incorporating an examination of economics, culture, political structures and social equity as well as natural systems and processes.

EE places a great deal of emphasis on problem solving (empowering students to take action), application of scientific knowledge to real-life issues and problems, and awareness of careers. It provides a rich context for learning because it encompasses many topics and academic disciplines.

EE also helps students to "learn how to learn. According to the Delors Report (Delors 1996) learning how to learn is based on the four pillars: *learning to know, learning to do, learning to be, and learning to live together*. An environment-oriented curriculum exposes students to activities that help them *learn to know* when they gather information about different environmental problems and issues from different sources. They *learn to do* when they select and apply the information and techniques suitable for solving problems or addressing issues. They *learn to be* when they make decisions or express their positions on particular issues, based on the information available. They *learn to live together* when they participate in community activities and communicate what they know and can do through practice and/or role modeling. The process of educating *about, for, and in* the environment enhances the ability of individuals to weigh various dimensions of environmental issues. EE does not advocate a particular viewpoint or course of action.

Effective integration of EE into the school program is therefore, a dynamic step towards improving teaching and learning and STL enhancement. Chapter 36 of Agenda 21 devotes a full chapter on 'Education, Awareness and Training,' which recognizes processes by which human beings and societies can reach their fullest potential (UNCED 1992). In the Thessaloniki Declaration, "education is humanity's best hope and most effective means in the quest to achieve sustainable development" (UNESCO 1997a).

## **Strategies to Promote EE**

Since EE is about awareness, attitudes and participation in environmental protection and resource conservation, it is inevitable that the "how of EE" involves learning experiences using the natural and man-made environment, both in the urban and rural areas and which encourages discovery and action. It includes activities that expose students to problem solving and decision making, using community situations in the early years and expanding experiences to global concerns as they mature (Garcia 2001; May 2000).

Traditional classroom activities like laboratory work followed by lecture and discussion are still useful but interactive learning through the use of games and simulations, debates, field activities, concept mapping, issues analysis and journal making have been shown to be

more interesting to students. These strategies help them clarify their own values and enhance decision-making skills.

The most effective locale where students are exposed to EE is outside of the classroom - in the home, in the school and in the community including industrial sites. Studying the plants and animals in the garden, monitoring the quality of water in a river or lake, observing biodiversity in a nearby forest, making a case study of the sanitary landfill or dumpsite, or recycling solid wastes are just a few examples of experiential learning. Students express what they observe through writing or oral expression and analyze how the conditions came about. Furthermore, they reflect on their own behaviors whether or not they contribute to the problem or situation observed.

Table 1 summarizes the science concepts, inquiry skills and environmental attitude developed using the lesson “Effects of Gas Exhaust on Plants”. This lesson has been tried out in elementary school science (ESS-Grade 5) and high school science (HSS- Year 1). It is good for 2-class periods. The numbers indicate the sequence by which the topics and activities are developed/implemented for each grade level. In the last column, one asterisk means the activity is suitable for ESS and two asterisks means it is for HSS.

**Table 1. Effects of Gas Exhaust on Plants: Summarized Lesson Activities**

<b>Science Content and Inquiry Skills for ESS</b>	<b>Science Content and Inquiry Skills for HSS</b>	<b>EE Topics Integrated into the Lesson</b>
Formulating hypothesis on the effects of car exhaust on plants (2)	Components and properties of gases in car exhaust (2)	Observing cars/smoke belchers: discussion effects of gas exhaust on humans (1**)
Designing a procedure to test the hypothesis, using experimental and control setups (3)	Formulating hypothesis on the effects of car exhaust on plants (3)	Suggesting ways to reduce effects of car exhaust on plants (10*) (12**)
Establishing indicators of change in plants (4)	Designing a procedure to test the hypothesis using experimental and control setups (4)	Discussion on air pollution as a global problem (13**)
Collecting gas exhaust (5)	Establishing indicators of change in plants (5)	Explaining the meaning EE core messages of interconnectedness, change and stewardship based on the activity. (11*) (14**)
Conducting the experiment (6)	Collecting gas exhaust (6)	
Recording observations on a prepared data sheet (7)	Conducting the experiment (7)	Communicating the messages/ lessons to friends and family through posters and short write-ups. (12*) (15**)
Drawing conclusions from the observations (8)	Organizing data in a table students prepare themselves (8)	



<p>Discussing the importance of plants (9)</p>	<p>Drawing conclusions from the observations (9)</p> <p>Discussing the importance of plants (10)</p> <p>Discussion on how to maintain the car to reduce smoke and increase car engine efficiency</p>	
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Note that the lesson starts with observations of cars/smoke belchers (assigned a day earlier). The observations are used as motivation activity. The lesson develops skills in formulating hypothesis, designing a procedure to test their hypothesis and testing the hypothesis. It also emphasizes the need to establish indicators of change in plants before and after being exposed to the car exhaust. Naturally, there are more science concepts discussed in HSS than in ESS.

The lesson shows how to integrate not only science and environmental concepts but the cognitive, psychomotor and affective domains.

The choice of teaching and learning strategies is based on the characteristics of learners. In general, at the elementary level, children are curious and learn through their senses. They start to identify simple cause-effect relationships, enjoy pictures and different forms of art and media to express their feelings. They also like investigating objects in their immediate environment and love to share their experiences. At the secondary level, students learn the links between their lifestyle and components of the environment; they are more capable of explaining cause and effect relationships, learn to function as a member of a group and begin to understand social responsibility and thus desirous of becoming involve in decision-making. The emphases of EE therefore, is to develop environment- friendly persons at an early age so that they bring these habits and model the positive values as they mature and become environment-citizens. When they become adults and/or professionals, they can practice and/ or influence decision-making in their area of work towards sustainable production and environmental protection

As earlier mentioned, EE is an across the curriculum innovation. To make the integration of EE effective, teachers of different subjects areas must be conscious of the emphasis of their own discipline and the knowledge and skills they want students to acquire at different grades to reduce overlapping or over repeating concepts to the point of being redundant. Teachers across disciplines should also articulate among themselves what activities have been used in other subjects. One strategy is to analyze a particular topic in the curriculum and prepare an integrated plan where different subjects areas can participate in and develop relevant lessons. Another strategy is to analyze and follow the competency list for different subjects/grades and look for relevant lessons in EE suitable for the subject/grade level.

## **The State of EE in the Asia-Pacific Region: Issues and Concerns**

Interest in EE across the world is growing but good practice is not widespread (Fein & Tilbury 1996; UNESCO-Japan EE Reports 1996 to 2000; ADB et al. 1999; IGES 2001).

Almost all countries have national education policies that require the integration of EE topics, concepts and skills in the curriculum. Infusion into existing subjects is the main approach to promoting EE objectives. This approach does not entail changes in the curriculum structure and is viewed as a strength because the content of EE is relevant to the themes in many learning areas such as science and social studies. Environmental topics can also be used to develop skills in communicating, mathematics, and even the arts.

Only a few countries in the Asian region have developed the curriculum guidelines that can serve as templates for doing EE. There are many activities going on but these are not cohesive and unidirectional. In many countries, most initiatives still tend to favor nature conservation rather than the multidisciplinary concept of sustainable development and the holistic imperatives of a sustainable future. EE activities are initiated by Ministries of Science, Environment, Agriculture or Natural Resources and not by the Ministries of Education. The focus is on information and awareness-raising campaigns directed at individual behavioral change rather than broader educational or sustainability goals. The lack of interest of Ministries of Education explains the absence of a coherent plan for progression in EE from basic education to tertiary level. As a result, EE is often not a priority, especially as the curriculum is overcrowded. Moreover, EE concepts are usually not included as examination subjects. The interactive and experiential teaching strategies of EE are in conflict with the traditional classroom practices that emphasize recall of content and examination performance rather than development of problem solving and other higher- order thinking skills.

Instructional materials on different environmental problems/issues are available but in limited circulation. Oftentimes, critics question the accuracy and bias of the information received by young people about environmental issues. The example given in the beginning of this paper about the flu epidemic and speculation that it was due to a biological weapon supports this claim. Given the scarcity of EE-related textbooks and support materials, children and the community get information (often sensationalized) from inaccurate sources.

Many teachers attempt to integrate EE objectives and topics into their subject areas. However, the information overload, coupled with the complex and continuously developing state of environmental knowledge makes it difficult for teachers to present a coherent and balanced picture of the nature of an environmental problem, especially if they are not adequately trained. Teachers need training in carrying out discussions on issue-based topics.

The studies in the region also reveal that the problems stated are intensified by the lack of support for EE by policy makers, school administrators and teacher educators. Professional teacher organizations and nongovernmental organizations (NGOs) can assist in conducting in-service training on EE strategies. In addition media support is also necessary. Researches related to EE methodologies are likewise limited (Kawashima 1999). School and community linkage is minimal (Tan 1996). Therefore, EE programs are not sustained especially when

funds are not made available

International organizations are doing catalytic and supportive roles in promoting EE. UNESCO activities, for example, include identification of the type of information and key messages, preparation of exemplar teaching-learning and information materials based on up-to-date research findings, provide advisory services to countries on reshaping national education curricula, promoting relevant training to teachers, and other education providers and promoting educational activities with industries and other target groups. Broad international alliances in support of EE through partnership with other relevant organizations and key institutions worldwide have been formed.

The interdisciplinary UNESCO Chairs on environment and sustainable development in universities worldwide is unique. These chairs are interconnected through inter-university networks and twinning between universities (UNITWIN). Its Interdisciplinary Inter-agency Project: Education for a Sustainable Future is a major effort towards helping reshape formal education to become a major instrument of sustainable development and promoting information and public awareness- raising activities, using varied media (UNESCO 1997b).

UNEP also launched NETTLAP (Network for Environmental Training at the Tertiary Level in Asia and the Pacific) to enhance environmental expertise of decision makers, policy formulators and tertiary level trainers through a self-sustaining network of trained individuals in the region. Recently, it has refocused its existing EE activities around the concept of global environmental citizenship.

The Asia Pacific Cultural Center for UNESCO (ACCU, Japan) has sponsored a number of programs such as developing print and non-print materials to promote environmental awareness and action. The Project 'Package Learning Materials on Environment' (PLANET) has developed multimedia packages on Water, Forests and currently being developed is Solid Waste Management as part of the environmental literacy promotion in Asia Pacific.

Though there are many efforts to promote EE, the challenges are still enormous.

## **The Vision: Scientific, Technological and Environmental Literacy for All**

Environmental problems continue to rise (ADB 2001). Consequently, there is a need to develop a scientifically, technologically and environmentally literate citizenry. These citizens should eventually be capable of making sense out of what is going on around them. In addition, these citizens should be able to comprehend what is commonly referred to as the scientific approach or the scientific way of knowing and doing things. This implies that prejudice or ignorance does not prevail in determining whether or not a person endorses a smoke belching campaign or a nuclear power plant construction.

Curriculum developers now face the challenge of preparing learning episodes that are relevant and engaging to all types of learners. This encourages the development of a holistic and integrative approach to teaching and learning by applying the "less is more" policy. This suggests that content areas should now focus on the development and mastery of skills to empower citizens to lead a productive life and to enjoy the best possible quality of life. This

also means shifting away from rote learning to higher levels of cognition that leads to effective learning.

EE addresses these concerns for as long as efforts are directed towards promoting the value-laden environmental core messages that are to be internalized to develop positive behaviors toward the environment. In the Philippines, core messages that are applicable to any environmental problem were adopted as unifying themes consistent with the holistic and comprehensive nature of EE (ADB-DECS-DENR 1999). These can be embodied in an integrated school program representing a sequential type of learning based on a sound educational philosophy rather than focus on what educators describe as activity-guide mentality, picking and choosing an activity here and there.

The core messages are:

- Interconnectedness - Everything on Earth is connected to everything else. What one does affects others, directly or indirectly.
- Biodiversity and Stability - All life forms are important. The more diverse the ecosystem is, the more resilient is that ecosystem to change.
- Change - Changes continuously occur. There are changes that improve the quality of the environment; other changes degrade it. We have to avoid or prevent those changes that degrade the environment.
- Balance of Nature - Nature has its own laws to maintain and/or cleanse itself.
- Finiteness of Resources - Most natural resources are finite. Even those that are renewable are difficult to obtain or take hundreds of years to grow or develop. Resources have to be used prudently and wisely so that future generations can also enjoy them.
- Population Growth and Carrying Capacity - A given ecosystem can only support a specific number of individuals at a given time. If the carrying capacity is exceeded, an imbalance in the ecosystem will occur. The system will eventually reach a new equilibrium level but the quality of the ecosystem usually suffers.
- Materials Cycle - Materials are neither created nor destroyed. They are only converted from one form to another. Pollution occurs if the volume of the materials in one place is too much that the ecosystem's quality and usefulness is reduced.
- Stewardship and Cooperation - Resources must be used prudently and wisely so that future generations can also enjoy them. Each person should practice responsible environmental behavior.
- Sustainable Development - Economic development can be pursued but not at the expense of the environment.

While environmental problems can be dealt with within the framework of existing subjects in school education, some aspects may not be suitable for science or social studies, hence the need to develop teaching materials with a different perspective. There is a need

to generate support for EE in schools. Schools play an important role in nurturing environmental literacy but many parts of society shape attitudes towards and knowledge about the environment. Kawashima (1999) suggests the following:

- Environmental problems are ongoing but the cause and effect are not easy to identify. Education should attempt to address the problem even without pinpointing the cause and effect.
- It is important to convey the right information about environmental problems. Since this is not always possible, the future perspective must be emphasized, keeping in mind that even scientific predictions are uncertain.
- Environmental problems do not arise over a short period of time. Therefore, students must participate in observing experiments, research and other learning experiences related to on-going changes.
- Environmental problems are not remote to student experiences. Therefore, it is important to conceive these as problems adjacent to the social structure or system where they live.
- Problems in relation to environmental destruction are often discussed from the natural science point of view. At this point, there is a greater need for the social dimension of these problems to be emphasized more because these problems are largely caused by human activities.
- Most often, too much information is given to students and the overload may not allow these students to synthesize what had been learned. To reduce confusion, teaching materials should encourage experiential learning and self-learning.

In the IUCN-CEC Strategy (1997-1999), suggestions were made on how to improve EE in schools and communities by promoting the idea that environment and development are two sides of the same coin. Furthermore, it was suggested that indigenous knowledge, traditional methods and systems, and environment-friendly livelihoods should be utilized.

Finally, since many EE programs have been developed independently, there is a need for an information and exchange system among countries, schools and organizations. This would require an international network on EE with selected institutions to handle the e-database of materials available, on going training programs and researches on EE, including the formulation of guidelines/criteria for what 'good' EE materials and training should be. This would lead to strengthening of school and community linkages to enhance community education and service, awareness of the cultural sensitivities in the development of instructional materials and training designs; and promotion of the interconnectedness principle and the concept of biodiversity in programs and projects. All these activities are feasible with the current state of information and communication technologies.

It is envisioned that in this decade, a great majority of children and adults will be imbued with the sense of responsibility to care for, protect, and enhance environmental quality that is conducive to their well being and supportive of their nations' economic

development. It is important however, to start EE early in the child's life. EE based on real-life experiences shape life long attitudes, values and patterns of behavior toward the natural environment. The lyrics of a song The Greatest Love of ALL expresses this concern: "...the children are our future. Teach them well and they will lead the way..."

In an ideal world, scientific, technological and environmental literacy is a lifelong process. A strong foundation in elementary schooling will allow learners continue to adapt and adopt when exposed to a variety of learning experiences. The learners will be able to handle difficult circumstances based on the real-world setting, make interdisciplinary connections, accept cooperative and individual performances, identify process and content appropriate to the learners developmental level, able to assess risks and benefits while making choices; move towards self reliance; and make responsible decisions in real life situations (Tan 1999).

### **Concluding Statements**

Science and technology greatly affect our daily lives. We often use products because these products make our lives more comfortable. In many instances there are incidents which could bring danger to life and property, instances that can be prevented, managed or avoided. The continuing supply of natural resources can be assured whenever individuals are encouraged to learn how to discriminate between 'needs' and 'wants'. Appropriate actions and support to programs and projects may be provided by all sectors of society if some level of STL is acquired. .

EE is a holistic program to nurture and promote STL. It places a great deal of emphasis on problem solving (empowering students to take action), application of scientific knowledge to real-life issues and problems, and awareness of careers. It provides a rich context for learning because it encompasses many topics and academic disciplines. Understanding the interlocking economic, environmental and social problems and attempting to find solutions for them require not only a scientific and technological perspective but also a holistic and comprehensive approach and understanding.

EE can keep the child's natural love of learning alive. But implementing responsible and effective Environmental Education supportive of the aims of Science Education will not be easy. It relies on partnership and cooperation of all stakeholders at the local, national and international levels.

Pre-service and in-service training should focus on teaching for responsible action and autonomous thinking rather than activism with teachers learning how to become facilitators. The need for an information and resource exchange/sharing system through a network of institutions is necessary. This network can also do collaborative activities towards STEL enhancement through curriculum development, training and research.

STEL is not just important for education and the environment. STEL is also good for the community, for business, and for government. Using the environment as an integrating theme in curricula:

1. improves achievement in science and other subjects
2. increases student problem solving and critical thinking skills
3. increases enthusiasm and engagement in learning
4. provides students with opportunities to learn more about science and technology in the contexts of their daily lives.

As a result, more and more individuals learn how to become stewards of natural resources, active participants who are capable of reducing pollution because they understand what it means to innovate (using less to create more - reducing waste, cost and risk). STEL literates translate these knowledge and values into concrete action. In the long run, government will no longer have to spend a lot in cleaning up and maintaining the integrity of ecosystems that are essential for sustainable development and our survival.

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