Adult awareness of environmental degradation caused by technology : a component of Technological, Environmental and Agricultural Literacy (TEAL)

by Gregory Alan Hester

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor Of Education in Adult, Community and Higher Education
Montana State University

Abstract:
This study investigated the relationship between adults' attitude toward the environment and their awareness of the detrimental environmental impacts caused by certain commonly used technologies. A total of 396 usable responses for a return rate of 42.4%, were received from a mail survey of managers of Florida community associations (CAs) which are also known as condominium developments. Demographic data was collected along with responses to a modified New Environmental Paradigm/ Dominant Social Paradigm Scale, and the Technological, Environmental and Agricultural Literacy (TEAL) Survey which was developed for this study. Data analysis was conducted to evaluate the instruments and the characteristics of the population.

Both instruments were determined to be reliable and to possess content validity, though the TEAL survey was judged to be deficient in sampling validity. Factor analysis indicated that the TEAL survey measured four dimensions of awareness of harmful environmental impacts of technology which were Energy Literacy, Water Literacy, Waste Literacy, and Pesticide Literacy. The modified NEP/DSP scale was found to measure three factors included in attitude toward the environment which were Belief in Growth and Technology, Relationship between Humans and Nature, and Quality of Life. This was consistent with the findings of previous research using this instrument. Therefore, both instruments were found to have construct validity.

Analysis of the NEP/DSP scale supported the conclusion that a paradigm shift in the general population previously reported by others, is also occurring among adult real estate managers and that the belief that technology will ultimately be developed to solve all environmental problems is not widely held by members of this sample. Attitude scores, among the variables tested were found to be the best predictor of awareness, followed by gender. The relationship between attitude and awareness was found to be complex rather than linear. The majority of CA managers were found to be slightly to moderately supportive of the NEP. However, the awareness levels of CA managers was low. Cluster analysis determined that three distinct groups existed in the population, based on their shared beliefs and awareness levels. These groups were named Complacents, Concerned, and Committed.

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This thesis has been read by each member of the author's committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Chapter 1

INTRODUCTION

Background

The meaning of the term "literacy" as perceived by American adults has changed considerably during the decades since World War II. Literacy has traditionally been viewed as an indicator of whether a person has developed the ability to communicate effectively by reading and writing their native language. An individual has been deemed to be functionally literate if they could successfully perform such basic tasks as reading and comprehending a newspaper, or writing a letter which appropriately expressed the ideas they wish to convey.

Until rather recently, most adults also felt that possessing the basic competencies of reading and writing was enough to allow anyone to fully participate in a democratic society. However, the perception of which specific skills an adult must possess in order to be literate has evolved, and the majority of Americans now perceive literacy to include considerably more than just language skills. It is now widely believed that when a person is described as literate, it indicates that they possess a reasonable degree of

proficiency in using higher order thinking skills such as problem solving (Harris, 1970).

As society has become increasingly complex, researchers have attempted to identify the skills adults now require in addition to language arts, to function effectively. Investigations have attempted to document the need for adults to develop a variety of types of literacy. Three categories of literacy which have recently been the focus of increasing attention are technological literacy, environmental literacy (also know as ecological literacy) and agricultural literacy. For the purposes of this study, these three categories of literacy are referred to as TEAL.

Researchers have identified specific components of each of these categories. One attribute which has been determined to be a significant tenet of each of these literacy types is possessing the ability to recognize potentially harmful impacts to the environment which may result from the use of technology. Although several formal environmental education programs are now attempting to develop this trait in children, it is in fact, a problem which primarily affects adults, since they make far more choices regarding technology use than do children.

Indeed, every adult makes technological choices which have environmental impacts. However, adults who exercise control over substantial tracts of land such as farmers or

professional real estate managers, make decisions which have much greater impacts than an individual homeowner.

In Florida, for instance, managers of real estate developments such as condominiums, can require that all the residents of the development use certain technologies, such as low-flow showerheads. The technological decisions made by one such individual may impact the energy or water consumption of thousands of persons dwelling on hundreds of acres of land. Therefore, it is especially important that these managers develop satisfactory levels of TEAL.

Statement of The Problem

Since the dawn of The Environmental Movement in the early 1970's, adults have generally become more aware of the extensive harmful environmental effects which resulted when technology was used on a large scale without an adequate understanding of its environmental consequences. Extensive media reports about high profile sites such as the Berkeley Pit/Anaconda Smelter Superfund Site with an estimated clean-up cost of over 750 million dollars, have likely been seen or read by the majority of American adults.

However, what remains unclear is the degree to which adults recognize and understand the more subtle environmental impacts of their own individual use of technology. This trait is an especially important component

of TEAL, because profound environmental problems can be caused by the use of technologies such as the gasoline powered automobile, which has become such a major part of the everyday lifestyles of most adults in developed countries.

Because agricultural technologies are used on such large expanses of land, they are frequently blamed for environmental degradation in rural areas (Smith, 1991). However, agricultural technologies such as pesticides, commercial fertilizers and irrigation are also used on millions of urban acres. Pesticides are frequently used on urban lawns at a rate which is up to ten times the rate per acre used by farmers (National Academy of Science, 1980), so the improper use of agricultural technology can be a significant environmental threat in cities too. In fact, the United States Environmental Protection Agency has determined that the majority of pollution problems remaining in the U.S. are caused by numerous widespread "nonpoint sources" (USEPA, 1990) which include not only farms, but cities, suburbs, homes and small businesses as well. Though most of the environmental impacts caused by these individual sources appear at first glance to be insignificant, the damage they cause is substantial nonetheless, when considered collectively.

Despite the need to develop increased adult environmental awareness or TEAL, most formal education programs have focused on K-12 schools. Two notable recent exceptions are programs developed by the Cooperative State Research Extension and Education Services (CSRESS), affiliated with the respective Land Grant Institutions in each state. These programs are "Sustainable Agriculture" and "Sustainable Development". Until approximately a decade ago, Extension education programs focused primarily on economic issues such as increasing profitability with relatively little regard for environmental concerns (Rasmussen, 1989). But these new programming areas take a more holistic approach in that they are attempting to facilitate both knowledge increases as well as attitude changes (USDA,1995).

In order for these adult education programs to succeed in meeting their objectives, they must overcome some of the barriers that have prevented the behavior changes that other environmental education programs have attempted to promote. Two such barriers which have been identified are an indifferent attitude or lack of concern for the environment, and a lack of knowledge of human impacts on the environment (Gardner & Stern, 1996). Consequently, when adults use legally approved technology in a manner which results in environmental degradation, it is often due to one of these two reasons.

Therefore, an underlying assumption of many environmental education programs is that a person who becomes more informed or develops a higher level of TEAL, will develop more concern for the environment and thus, will become more likely to choose technologies which cause less harmful environmental impacts than persons who do not possess knowledge of those impacts. However, it has been shown repeatedly that possessing knowledge alone is not always sufficient to assure that the desired behavior changes occur. As a result, programs which simply provide knowledge for the learner are seldom successful, especially if the learner has a negative environmental attitude (Gardner & Stern, 1996). But, in cases where the learner has a pro-environmental attitude, learning experiences can be designed to help learners develop behaviors which are compatible with their attitude.

It is important then, to consider the adult learner's attitude toward the environment or overall environmental concern. Attitude in this situation, can be measured by ascertaining the degree to which one accepts or rejects certain critical concepts. Collectively, these beliefs comprise a person's attitude, worldview or paradigm. The first concept is that all environments including Earth have a biological carrying capacity which places limits on the amount of economic growth and development which can occur.

Second, is the idea that in order for humans to survive they must respect the balance of nature and try to live in harmony with it as opposed to pursuing a goal of man conquering nature. The last important component of attitude toward the environment is described as "belief in technology" or BIT (Dunlap & Van Liere, 1978). This is the concept that we need not be concerned about the natural environment, because technology will ultimately be developed to somehow mitigate any detrimental environmental impacts humans have caused before Earth becomes uninhabitable. Therefore, BIT may be a key factor which can influence an adult's reluctance to discontinue using environmentally damaging technologies.

Little is known about adult's awareness of how their technology choices impact the environment, and how it is related to their attitude toward the environment, including the degree of confidence which an individual places in technology's ability to solve environmental problems.

It is also unclear whether the level of awareness of technology-caused environmental impacts has been effectively increased in adults who have participated in traditional continuing education courses offered by Extension and other providers such as Real Estate Schools. For example, do real estate managers who have more formal education or more on-the-job training in property management techniques, have a

greater awareness of technological impacts than less educated individuals? Do more experienced managers have greater concern for the environment than less experienced real estate managers? Are real estate professionals who manage property for appearance and aesthetics literate concerning the use of agricultural technologies such as fertilizer and pesticides on the landscape? Do female property managers possess higher levels of TEAL than male managers? Finally, do adults who have a greater concern for the environment tend to be more aware of the harmful effects of technology?

If adult educators working with this target audience were able to answer these questions they could be better prepared to begin the process of selecting appropriate educational methods to facilitate the development of higher levels of TEAL. Accordingly, in order to design meaningful instructional strategies, adult environmental educators need to consider both the cognitive and affective domains. To plan programs which can be effective in reaching their goal of motivating desired environmental behavior, it is essential that adult educators assess the level of a learner's knowledge as well as their attitude.

Purpose of the study

The purpose of this study was to measure the relationship between attitude toward the environment and awareness of the harmful environmental impacts of technology use. In addition, the study measured the relationship between awareness of the harmful impacts of technology use and the personal descriptors of age, gender, educational level, and years of training or experience in property management.

General Questions to be Answered

(1) What is the general attitude of professional real estate managers toward the environment?

(2) Do professional real estate managers support the concept that technology will be developed to solve all environmental problems humans create before that damage becomes irreversible?

(3) What is the level of awareness by professional real estate managers of the detrimental environmental impacts caused by certain commonly used technologies?

(4) Is there a relationship between awareness by professional real estate managers of the detrimental environmental impacts of technology and their attitude toward the environment including belief in technology?

(5) Does awareness by professional real estate managers of the detrimental environmental impacts caused by technology interact with their personal traits of age, educational level, gender, and years of experience managing real estate?

(6) Among professional real estate managers, can representative groups be identified based on their awareness of detrimental environmental impacts caused by technology and their attitude toward the environment?

Significance of The Study

Numerous experts have reported that we are losing our battle to protect our environment. Problems which are rated as most significant by scientists at the United States Environmental Protection Agency include global warming/climate change, loss of biodiversity, and nonpoint sources of air and water pollution (USEPA, 1990). Each of these problems is due primarily to the cumulative contributions of millions of persons across the nation who seem unaware that their lifestyles create demands for technologies which produce environmental pollution problems. Therefore, the goal of numerous informal educational programs has been to enable learners to increase their understanding of technological impacts on the environment and to develop an attitude which fosters concern and a

willingness to take action to remedy the problem. In short, the goal is to develop citizens who are technologically, environmentally, and agriculturally literate (USEPA, 1991).

Traditional environmental education programs have been based on the assumption that the learner had little knowledge of the relationship between technology and the environment. So, they have tended to focus only on the cognitive domain. These pedagogical methods may not be appropriate for adults, and have generally been unsuccessful at achieving their goal of increased environmental literacy (Hungerford and Volk, 1990). Other educational efforts have attempted to change attitudes by increasing concern or environmental sensitivity, but have achieved almost no long lasting effects (Gardner & Stern, 1996). Since research has shown that knowledge of environmental problems is a required prerequisite to action, and that attitude is also significantly related to environmentally responsible action (Hungerford and Volk, 1990), there may be a relationship between attitude and knowledge.

The researcher located only one study which compared these two variables (Ramsey & Rickson, 1976), but it did report a significant correlation between attitude and knowledge of large scale pollution problems widely reported in the media. However, since this study dealt only with high school students, it could not conclude that such a

relationship also exists in adults. Therefore, one contribution of this study was to determine whether attitude toward the environment is related to awareness of less well publicized pollution problems caused by one's own decisions regarding technology use. This study also evaluated whether the same positive correlation between attitude and knowledge which the authors found in teenagers, exists in mature adults. In other words, the study measured whether adults who have become more aware of the harmful environmental effects of technology, have also tended to develop a more positive attitude toward the environment. If it could be established that these two traits are highly correlated, an adult educator might be able to use the same instrument which is valid for measuring attitude as a valid measure of awareness as well.

A second benefit of the study was to help determine the validity and reliability of a modification of a proven instrument for measuring attitude toward the environment, the New Environmental Paradigm/Dominant Social Paradigm scale (NEP/DSP scale), by testing it on a previously unstudied population. The modified NEP scale had been repeatedly tested on the general population, college students, farmers and members of environmental organizations. The DSP scale had also been tested and proven reliable and valid, but neither had been used on the

population in this study. Since real estate managers must pass certification tests to become licensed, they may have developed an understanding of environmental protection methods for property under their control which may distinguish their awareness level and attitude from members of the general public. Consequently, this study helped to identify characteristics of a population of adult learners which had not previously been measured in this manner.

Another contribution of the study was the development of an instrument, the TEAL survey, to measure a specific component of TEAL, identified as adult awareness or understanding of the harmful environmental impacts cause by certain commonly used technologies. The study helped to establish that the newly developed instrument can produce a valid and reliable measurement of that trait in adults. Since one main goal of adult education is to facilitate decision-making skills and self-discovery in the learner, it is essential to develop techniques and instruments such as the one developed for this study, which can give the educator an increased understanding of how to "learn from the people and start their education where they are" (Adams, 1975, p. 206). Furthermore, this study provides evidence that this instrument can be used as part of an adult learner's process of self diagnosis which was recommended by Knowles (1980) to provide "the highest level of individual

motivation" (p. 227). Adult educators who use appropriate instruments will be better prepared to help the learner determine what steps to take to help the learner move toward the goal of increased TEAL.

In most tradition Extension education programs, instruction has usually been delivered without conducting any type of valid assessment to determine the status of the target audience regarding both attitude and knowledge, prior to entering the educational experience. Therefore, a final benefit of the study is to provide a model which can help Extension educators to make appropriate assessments of adult audiences for designing educational offerings in two major program areas that directly relate to efforts to increase adult TEAL. The program areas of Sustainable Development and Sustainable Agriculture will be profoundly important to furtherance of the mission of the CSREES in the 21st Century. Since Extension programming has been criticized for using a one-size-fits-all approach in the past, this study can help educators to modify methods of instructional design to focus on the needs of the learner, unlike traditional Extension programs, which too often focused solely on subject matter content.

Developing sustainable systems is critical for the future. This will require the development of citizens with high levels of TEAL in both urban and rural adult

populations. Evidence of this is seen in Montana, by the fact that farmers and ranchers control technology use on more than 1/3 of the land, some 60 million acres. While in urban, heavily developed areas, the population is more dense, so the cumulative effects of technology use are concentrated. Consequently, it is imperative that adults in all areas develop an understanding of technological impacts and become informed consumers of technology, aware of the consequences of their choices. The decisions to promote adoption of benign technologies and to reject destructive ones will require democratic participation of large numbers of adults acting in communities. Accordingly, this study has widespread applicability to the field of adult education.

Limitations and Delimitations

The proposed study was conducted under the following restrictions:

(1) All persons in the population sample were asked to participate voluntarily. Since some managers of community associations (CAs), also known as condominium developments, chose not to participate, the sample may not exactly replicate the attitude and awareness levels of the entire population.

(2) No instrument for measuring adult awareness of the harmful environmental impacts of technology was available to the researcher. Therefore, the researcher was limited to basing conclusions regarding this trait to answers ascertained by an instrument developed to serve that purpose in this study. This was accomplished by utilizing the expertise of engineers, faculty and Extension Specialists at the University of Florida. The instrument was delimited to questions measuring the participant's knowledge regarding only those technologies which are commonly used by property managers.

(3) Since the results of the survey were self-reported, the participants may have chosen to provide answers which are not accurate or may not correctly describe the personal traits of the participant. This may have skewed the results of the study.

(4) The study was delimited to only those individuals who were listed by the state of Florida as licensed to manage CAs at the time the survey was mailed in July, 1995.

(5) The study was delimited to only those subjects who manage CAs, in the state of Florida. Persons who manage farmlands, forested lands, or other real property were not surveyed.

Definition of Terms

The following definitions are provided based on the manner in which the term is used with regards to this study.

(1) Agriculture -- The science of cultivating the soil and of supplying nutrients and water for the purpose of producing plants, which in this study includes only turf and ornamental plants.

(2) Agricultural Literacy --

> Understanding and possessing a knowledge of our food and fiber system. An individual possessing such knowledge would be able to synthesis, analyze, and communicate basic information about agriculture. Basic agriculture knowledge includes: the production of plant and animal products, the economic impact of agriculture, it's societal significance, agriculture's important relationship with natural resources and the environment, the marketing and processing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products (Frick, 1991, p. 41).

(3) Attitude toward the environment -- The degree of concern an individual feels for the environment as determined by their worldview or acceptance of a paradigm regarding (a) the balance of nature; (b) mankind's right to conquer nature or exploit natural resources; (c) the biological limits or carrying capacity of an environment; (d) the need for economic growth, prosperity, and progress; (e) belief in private property rights and limited

government regulation; and (f) belief in technology. The Two extremes of attitude are represented by the New Environmental Paradigm (NEP) and the Dominant Social Paradigm (DSP) (Dunlap & Van Liere, 1978).

(4) Belief in Technology (BIT)-- An acceptance of the idea that humans will always through the application of science, be able to develop technology which will be able to prevent or mitigate any harmful effects to our environment before the damage becomes irreversible or our ability to survive as a species is jeopardized. BIT is one component of attitude (Dunlap & Van Liere, 1978).

(5) Community Association -- A legally organized group of owners of condominiums who jointly own common areas of property in the same building or on the same grounds.

(6) Dominant Social Paradigm (DSP) -- an attitude or worldview widely accepted by the American public after World War II. It is characterized by the following set of beliefs: (a) Humans have a right to use natural resources, because they were created for human benefit; (b) the balance of nature will not be upset by human intervention; (c) the biological limits or carrying capacity of

an environment can be overcome by the application of better technology; (d) it is necessary for our economy to continue growing to insure prosperity and progress; (e) the government must not interfere with private property rights by adopting environmental regulation; and (f) technology will be devised to solve any human-caused environmental problems (Pirages & Ehrlich, 1974, p. 44).

(7) Dominant Social Paradigm Scale (DSP Scale)-- An instrument developed to measure attitude, specifically the degree to which an individual accepts the beliefs which constitute the DSP (Dunlap & Van Liere,1984).

(8) Environment --The natural world in which all living creatures exist including the air, water, soil, all plants and animals (McKinney & Schoch, 1996).

(9) Environmental Literacy --
The capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems. This includes having an understanding of the relationships between natural and social systems, the unity of mankind with nature, technology and the making of choices, and developmental learning throughout the human life cycle (Disinger & Roth, 1992, p. 2).

(10) Environmental Movement -- The shift in the American population'sview of their relationship with the environment. This change began around the time of the First Earth Day on April 22, 1970. It has these goals:

> (a)the safety and good health of individuals,including their psychological well-being as affected by the natural environment
> (b) the long range survival and welfare of society, including the life-supporting environment on which these depend,
> (c.) the achievement of a richer and fuller life, including desirable environmental characteristics (Odell, 1980, p. 5).

(11) Literacy-- Being literate which is having the ability to read and write, and having the ability to respond to the problems of everyday life (Harris, 1970).

(12) Nonpoint Source Pollution -- degradation of air or water due to an accumulation of numerous contaminants from widespread, difficult-to-pinpoint sources over a large geographic area (USEPA, 1991).

(13) New Environmental Paradigm (NEP) -- An attitude or worldview which began to become more widely accepted by the American public after the start of The Environmental Movement. The NEP is

characterized by the following set of beliefs: (a) Humans have no right to exploit natural resources, because humans exist as a part of nature not the conquerors of nature; (b) the balance of nature can be upset by human intervention; (c) the biological limits or carrying capacity of an environment cannot be exceeded; (d) it is necessary to place limits on economic growth and to develop a steady state economy; (e) the government must be allowed to restrict private property rights to protect the environment which sustains life; and (e) humans cannot depend on technology to solve every environmental problem (Dunlap & Van Liere, 1978).

(14) New Environmental Paradigm Scale (NEP Scale)-- An instrument developed to measure attitude, specifically the degree to which one accepts the beliefs which constitute the DSP (Dunlap & Van Liere, 1978).

(15) NEP/DSP Scale -- An instrument which modified and combined both the NEP Scale and the DSP Scale to measure attitude, containing statements referencing beliefs in the DSP and the NEP (Kuhn & Jackson, 1989).

(16) Sustainable Agriculture--

An agriculture that can evolve indefinitely toward greater human utility, greater efficiency of resource use, and a balance with the environment that is favorable both to humans and to most other species (Harwood, 1990, p. 18).

(17) Sustainable Development --

Development that focuses on making social, economic, and political progress to satisfy global human needs, desires, aspirations, and potential without damaging the environment (McKinney & Schoch, 1996 p. G-13).

(18) TEAL -- An acronym for technological, environmental, and agricultural literacy.

(19) Technology --

The human activity in which physical means that extend human capabilities are used to purposefully address the satisfaction of human wants and needs (Dyrenfurth and Kozak. 1991, p. 152).

(20) Technological Literacy --

The possession of broad knowledge of technology together with the attitudes and physical abilities to implement the knowledge in a safe, appropriate, efficient, and effective manner. Technological literacy requires that one be able to perform tasks using the tools, machines, materials, and processes resulting from technology (Dyrenfurth, 1987, p. 22).

Chapter 2

REVIEW OF LITERATURE

Literacy

The concept of "literacy" is multi-faceted and difficult to define. The complexity of the task of accurately describing the many aspects of literacy was noted by Brandt (1985, p. 128).

> It is tempting to observe in an overview how scholars working elbow-to-elbow on the same problem rarely seem to converse with each other, or how the diversity of their method--from broad political speculation to detailed ethnographic description--wards off any certain and truly interdisciplinary conclusions about the nature of literacy.

Despite this widespread disagreement among disciplines as to what prerequisites are essential to be a literate adult, possessing two fundamental skills are unquestionably mandatory. In order to be literate an adult must be capable of both reading and writing at an effective level. Possession of these skills is the essence of literacy as it is traditionally associated with the field of adult education (Brandt, 1985).

Numerous programs designed to teach literacy to adults across the United States are conducted by a variety of institutions, including colleges, high schools, Job Corps

Centers, prisons, and others. These programs provide Adult Basic Education (ABE), which focuses on developing an adult's ability to read and write adequately as measured by a standardized General Equivalency Diploma (GED) test. Though state minimum scores for earning the GED vary, passing this test has long been viewed as proof that an adult has developed sufficient language skills to be considered literate.

However, the belief that the development of communication skills alone is sufficient preparation for an adult to become literate has often been disputed. In fact, even when discussions of literacy have been limited to only these skills, perceptions of literacy have varied greatly. Van Dyke (1987) observed that:

> What it means to be literate---even what it means to read and write---varies according to period and culture. Roman Orators, for instance, could be literate in spoken language; medieval scribes, literate by profession, could write the letters of the alphabet, but could not comprehend what they wrote (p. 2).

Accordingly, literacy as conceived by the American public is a trait which can no longer be adequately explained only in terms of one's ability to recognize and reproduce letters and words. Harris (1970) found that for an adult to be considered literate they had to possess "the ability to respond to practical tasks of daily life" (p.10).

Pattison (1982) also took a nontraditional view of literacy and referred to the idea that language skills should be the sole basis for determining whether an adult is literate as a fallacy. He noted that reading and writing do not constitute literacy, they are only the means of manifesting it. He explained that "literacy more fundamentally, is about consciousness of the problems posed by language" (p. vi). He advocated describing literacy more in terms of encompassing an understanding of what possibilities that communication skills opened for adults.

Oxenham (1980) had earlier referred to literacy as "simply a technology invented for certain practical purposes...the technology of the Intellect" (p.84). And though he felt it was the one most important tool or technological resource which has the power to create opportunities to develop skills in reasoning and increased self consciousness, it was not the one and only key to success in life.

This rather common assumption regarding literacy, that reading and writing skills in and of themselves are able to fully empower adults, was also debunked by Van Dyke (1987):

> If the traditional definition of literacy has been challenged, so have common ideas about its effects. In particular, scholars tell us, literacy is not inherently liberating. That is, increases in the ability to read and write do not always correlate with individual empowerment, economic development, or democratic government (p. 3).

This idea was also criticized by Graff (1979) who described it as "the literacy myth" (p. 304). He found that there was no significant relationship between attaining only the traditional literacy skills of reading and writing, and attaining increased economic status. He concluded that other factors including the development of verbal communication and reasoning skills were vital to allow adults to function effectively in society.

Therefore, the concept of literacy has changed from one in which it was seen as a specific set of skills that one could obtain to become literate for the rest of their life, to one which sees the task of being literate as an ongoing dynamic process. This concept was described by Greene (1982) "literacy ought to be conceived as an opening, a beginning, never a fixed end" (p. 326). A current view of literacy then, includes far more than basic language skills. In order to fully participate in our society, in other words to be a literate adult in the information age, one must develop a variety of skills. This process is lifelong and involves developing understanding and proficiency in a variety of types of literacy.

Due its inherent ambiguity, literacy has been the subject of numerous studies and many definitions of literacy types have been developed. Several researchers have made

efforts to quantify those skills which are deemed to be essential for adults to lead a fulfilling and productive life, and to document the need for including them in an adult education program. The focus of this study is one particular aspect which has been identified as important component of three types of literacy, the ability of adults to recognize the harmful environmental impacts of commonly used technologies. This skill has been deemed to be vital for the development of technological, agricultural and environmental literacy (Devore, 1986; Frick, 1991; Roth, 1992).

Environmental Literacy

The United States Congress officially recognized that developing environmental literacy was worthwhile when it passed the United States Environmental Education Act which President Bush signed in 1990. Implementation of this law has been directed by the Environmental Protection Agency which produced a mission statement proclaiming that "As improvements in environmental protection become dependent upon the activities of individuals so grows the need for an environmentally literate citizenry" (USEPA, 1991, p. 3). The EPA did not define environmental literacy.

But, Disinger & Roth (1992) found that although the term environmental literacy had been used for more than 20

years, it still lacked precision. They described the term as one which draws its meaning from six major content areas: "environmental sensitivity; knowledge; skills; attitudes and values; personal investment and responsibility; and active involvement" (p. 2).

Roth (1992) conducted a Delphi study in conjunction with the Committee on Environmental Education of the American Society for Testing and Materials (ASTM) to attempt to define and set standards for measuring environmental literacy. One conclusion of the study was a general definition of environmental literacy:

> The capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems. It includes an understanding of the interrelationships between natural and social systems, the unity of mankind with nature, technology and the making of choices, and developmental learning throughout life (p. 12).

Roth distinguished between individuals who were only environmentally aware and those who were environmentally literate. He concluded that environmental literacy includes an action perspective, in that all environmentally literate citizens "should be able to demonstrate in some observable form what they have learned--their knowledge, skills acquired, disposition toward issues and the like" (p. 25). He further reported that environmental literacy exists as a continuum with different levels of proficiency. The three

levels of environmental literacy in ascending order are nominal literacy, functional literacy and operational literacy. The highest level identifies a person who:

> has moved beyond functional literacy in both the breadth and depth of understanding and skills who routinely evaluates the impacts and consequences of actions: gathering and synthesizing pertinent information, choosing among alternatives, and advocating action positions and taking actions that work to sustain or enhance a healthy environment (p. 26).

This level of literacy is the goal of most environmental education programs such as those supported by the EPA as part of the National Environmental Education Act.

The ambiguity over what makes a person environmentally literate is illustrated by two comments made by William Reily, the former director of the USEPA. In 1990, he stated that "the public...has come to an unprecedented awareness of the threats to our environment" (Reily, 1990, p. 4). Just two years later, he noted that the amount of used motor oil Americans dumped into landfills or poured into storm drains in 1988, was equal to 16 Exxon Valdez oil spills (Reily, 1992, p. 37). The failure of so many persons to take appropriate action in disposing of waste motor oil is evidence that far too many adults are still not environmentally literate. Similarly Hungerford, Litherlan, Peyton, Ramsey, Tomera and Volk (1985) felt that motivation to take action is required for environmental literacy.

> The environmentally literate citizen is able and willing to make environmental decisions which are consistent with both a substantial quality of human life and an equally substantial quality of the environment. Furthermore, this individual is motivated to act on these decisions either individually or collectively (p. 1).

Therefore, an adult who does not act after becoming aware of environmental problems is not fully literate.

Science literacy differs from environmental literacy in that it is more focused on understanding basic natural phenomena, the laws of the physical and biological sciences which control our universe rather than the technology we have created by our understanding of how to apply science to solve problems. However, though science literacy is less broad in scope, both include action as a part of literacy.

> Scientifically literate persons are objective, open-minded and questioning. Their knowledge and inquiry skills make it possible for them to interpret science-related information presented in the popular media (newspapers, television, etc.)...and most of all they are critical thinkers and decision makers--they ask questions, seek answers, study consequences, and act on the basis of the best information available (Reichard, 1985, p. 110).

Agricultural Literacy

The National Research Council issued a report on agricultural literacy (NRC,1988) which acknowledged that "most Americans know little about agriculture... particularly, its link to human health and environmental quality" (p. 9). This concept was later evaluated by Frick

(1991) in a Delphi study which produced a definition of agricultural literacy.

> Agricultural literacy is understanding and possessing a knowledge of our food and fiber system. An individual possessing such knowledge would be able to synthesis, analyze, and communicate basic information about agriculture. Basic agriculture knowledge includes:the production of plant and animal products (divided into separate concept areas in the concept questionnaire), the economic impact of agriculture, it's societal significance, agriculture' important relationship with natural resources and the environment, (divided into separate concept areas in the concept questionnaire), the marketing and processing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products (p. 41).

Five-hundred ninety concepts were submitted for potential inclusion in a comprehensive definition of agricultural literacy. Two of the 11 agricultural literacy concept areas which were identified in this study are closely related to the concept of environmental literacy. They are agriculture's important relationship to the environment and agriculture's important relationship with natural resources (p. 45).

These concept areas were further refined into sub-areas. The sub-areas contained in the subject area of agriculture's important relationship with the environment are:

(1) The agriculturalist's role in protecting the environment

(2) The effect of agriculture on the environment

(3) Opinions and perceptions

(4) Chemicals

(5) Positive effects of agriculture on the environment

(6) Negative effects of agriculture on the environment

(7) Environment's close relationship with agriculture

The sub-areas contained in the subject area of agriculture's important relationship with the natural resources are:

(1) Conservation of natural resources

(2) Sustainable agriculture

(3) Stewardship of agriculture

(4) Pollution and depletion of our natural resources

(5) Co-dependent relationship between agriculture and natural resources

(6) Importance of natural resources for agriculture

Accordingly, several ideas which Frick identified during the process of defining agricultural literacy are concepts which are components of technological and environmental literacy as well. These include the notion that agriculture technologies have an impact on the environment which can be negative, and that it is essential that sustainable agriculture systems be developed which maintain water quality and the balance of oxygen and carbon dioxide in the atmosphere for plants and the human race to

survive (p. 49). It is also necessary in order to be agriculturally literate that one understands "the importance of human being's role (technology) in managing our natural resources to provide food, fiber, and shelter" as well as other human needs (p.59).

Frick (1991) indicated that some participants in defining the term agricultural literacy promoted the belief that "ranch and farm operators are very conscientious and concerned about the environment" (p. 47). However, other studies have tended to contradict this assertion. Albrecht, Bultena, Hoiberg, and Nowak (1982) surveyed 441 farmers in Iowa in 1979, and 1980, to measure their attitude toward the environment. They noted that previously "research has consistently shown farmers to be less environmentally aware and concerned than nonfarm populations" (p. 41). Their study also found that the general public was significantly more concerned about the environment than the farmers they surveyed.

Walter & Reisner (1992) discovered that significant numbers of incoming freshmen, especially those from urban areas were either unwilling or unable to express an opinion on a wide range of environmental or conservation issues. They concluded that "even agriculturally literate students could profit from challenges to their percieved beliefs about agricultural practices and policies" (p. 19).

A Kansas State University study of swine producers found that less than 1/2 realized that nitrates in hog waste were an environmental problem, and only 1/4 were concerned about phosphorus in hog waste though it is the most significant nutrient increasing algal blooms and eutrophication of lakes (Riechert, Tokach, Goodband, and Nelssen, 1995, p. 2). Bruening (1991) concluded that the level of agricultural literacy among farmers was less than desirable. Padgitt and Petzelka (1993) agreed:

> Overall, farmers are limited in their awareness of farm specific environmental problems...research reveals that, while farmers are generally aware of environmental and sustainability problems, not all are mindful of or believe the specific problem relates to them. More efforts are needed to increase farmers' awareness of environmental problems on their land (p. 277).

Agricultural literacy levels are also inadequate among urban populations as well. The Environmental Studies Board of the National Academy of Sciences, found that "homeowners use ten times more pesticide per acre than farmers-about five to ten pounds per acre" (National Academy of Sciences, 1980, p. 2). This results in a total of some 70 million pounds being applied annually to American lawns.

These studies clearly indicate that agricultural literacy needs to be increased in both urban and rural adult populations, including raising awareness of the potential environmental harm caused by agricultural technologies.

Technological Literacy

Scholars have for decades realized that technology's interaction with the environment needed to be better understood by adults. Carson (1962) observed that many of the most alarming environmental problems which began to appear in the second half of the twentieth century developed because technology had been placed "indiscriminately into the hands of persons largely or wholly ignorant of their potentials for harm" (p. 13). The concept of how technology shapes our culture and the need for its control was also recognized by Skinner (1972):

> We are all controlled by the world in which we live, and a part of that world has been and will be constructed by men. The question is this: Are we to be controlled by accidents, by tyrants, or by ourselves in effective cultural design (p. 149).

He recognized that for the latter to happen, it would require that technological literacy, although he never referred to it by that term, be developed in significant numbers of adults. Waks (1987) described the need for a technologically literate critical mass to ensure that political decisions reflect a cross section of informed democratic participation. He concluded that technological literacy is absolutely a "prerequisite of liberty and equality in a technology dominated age" (p. 366). Technological literacy then, is a concept far more encompassing that just understanding how to use a computer.

Consequently, the task of defining technological literacy has long been recognized as a very difficult challenge. "Our Search for a universal operational definition of technological literacy is probably futile" (Van Dyke, 1987, p. 4). However, that has not stopped educators from attempting to reach consensus on the term.

The National Technological Literacy Conference defined the term as "Understanding the technological and scientific forces shaping our lives and being able to act on this understanding for our personal welfare and the common good" (Steele, 1987, p. 738). Four years later the National Council for Technology Teacher Education expanded the concepts in more detail and devoted their entire 1991 Yearbook toward refining the many facets of this complex idea. They determined that technological literacy is based on the following components:

A. Democratic needs since:

(1) Our society is based on knowledge and knowhow.

(2) Citizens require certain forms of literacy to function effectively as free responsible members of society.

(3) People have a right to have a voice in determining their future.

B. Nature of life in society since:

(1) Survival depends on our capacity to apply rationality in solving problems within the environment.

C. Dehumanization and loss of control since:

(1) Technology is a powerful force which dehumanizes life by placing increasing demands on humans which have grown beyond our understanding and control.

(2) Technological decisions which control lives are often made by experts at a distance rather than with input from locals.

D. Impacts of technology since:

(1) Technology affects individuals, specific cultures and society in general, as well as the environment that makes our lives possible.

Devore (1984, 1987) described technology generally as the application of resources (time, tools, materials, and energy) by humans toward solving problems. Dyrenfurth and Kozak (1991) took this concept a step further to view technology as a human activity using physical means that extend human capabilities to satisfy human wants and needs (p. 152). In either view, basic technological literacy requires that one be able to perform tasks using the tools, machines, materials, and processes resulting from technology

(Dyrenfurth and Mihalevich 1987, p. 22). Todd (1987) proposed that technological literacy like environmental literacy, exists as a continuum with different levels of development and problem solving abilities. In Todd's model, the highest level of literacy is technological criticism (p. 775). He viewed a person who had attained this level of skills as a valuable community member who could collaboratively make technology choices.

Devore (1987) agreed and reiterated that the increasing urgency of developing sustainable systems will require that citizens be more involved in the participatory nature of community decision-making. He felt that technological literacy will be a basic necessity and that acceptance of greater individual responsibility along with continuing personal growth and lifelong learning will be vital. He also viewed the present dysfunctions of our society as the direct result of the inappropriate use of technical means that are rapidly depleting Earth's nonrenewable resources. He warned that continuing to place the decision-making authority for the use of these technical means into the hands of a few persons which he described as 'the elite', is a mistake:

> a technologically illiterate citizenry will promote the demise of democracy and place in control an elite group of people who, by their knowledge and know-how, will control the technical systems and thereby the possession of public and private life nationally and internationally as well (p. 712).

Fleming (1989) agreed that adults should develop the higher order thinking skills required to be critical of technology. He argued that literate persons should realize that no technology is completely understood and that we too often depend on someone else to inform us about technology rather than acting by examining both the pros and cons to "perceive the underlying political and social forces driving the development of technology" (p. 394). He used the analogy of elites, cattle barons who successfully opposed the use of a very simple technology, barbed wire fences for decades by the counter elites, farmers. Ultimately, acceptance of this technology aided in the downfall of cattle companies as well as the cow culture which had developed on the western plains. The results were that after a decision regarding technology was made in a democratic manner it aided in the emergence of a more diverse society and economy based on grain production and other farming ventures rather being totally dependent on the sole commodity of beef. He lamented that today many people "feel that whatever they have to say about technology will likely have little impact, but this sense of impotence in a democratic society must be addressed" (p. 403).

The need for higher levels of technological literacy and more participation in technology choices was also

promoted by Miller (1986) who reminded us that a technologically literate person "should understand that in democratic societies, citizens have some say about which technologies should be advanced and which should be restrained" (p. 200). Likewise, Winner (1977) stressed the importance of citizen participation in the setting of limits on environmentally harmful technologies and looked forward to the time when America, in reflecting on the age in which we realized the importance of developing technological literacy, would remember it as "the time when we came to our senses" (p. 13). Winner (1986) later observed that even "choices about supposedly neutral technologies...are actually choices about the kind of society in which we will live" (p. 375). Ferre' (1988) concurred and further explained that:

> even private decisions on technology, when they have profound effects on persons now living or in future generations and when they have significant impact on the environment, are rightly subject to citizen participation. Just as your freedom to smoke ends where my lungs begin so an electric utility's plan to erect a smokestack ceases to be merely private where my view, property values and health are affected (p. 87).

Hull (1990) analyzed the sociotechnical dimension of technological literacy and came to a similar conclusion. He stated that significant changes in technology use always have had unintended and unforeseen environmental consequences. Thus, decisions about technology are always

made within a context of uncertainty. Increasing levels of adult technological literacy can reduce this uncertainty.

Devore (1986) also argued that only citizens who understand technical systems can make intelligent decisions about their use or the need to replace them with systems which are more appropriate. He urged that the perpetuation of "problem plagued technologies" (p. 203) be terminated through knowledge as well as the analysis, synthesis, and application of values.

Fielder (1992) pointed out that there are some cases where technologically literate persons have been able to bring about pro-environmental actions such as preventing the dumping of toxic waste near populated areas, by actively challenging the decision making institutions which those persons regarded as captives of technological interests.

But, for the most part the degree of participation by citizens has been minor. Sclove (1992) observed that each of us has made a contribution toward building the world which exists. He argued that our citizenry must become more critically involved in choices about technological practices and faulted the current system or technological order that he described as an arbitrary, anti-democratic social force which "excludes citizens from anything but a trivial role and often raises questions publicly only after important decisions have already been made elsewhere"(p. 153).

This conclusion was also reached by Postel (1994) who found that citizens have not assumed this much-needed control of technology. Rather, we have been content to allow economics to serve in the role of decision-maker for us.

> As a society we have failed to discriminate between technologies that meet our needs in a sustainable way and those that harm the earth. We have largely let the market dictate which technologies move forward, without adjusting for it's failure to take proper account of environmental damage (p. 41).

Bugliarello (1990) believed that our inability to use technology in a environmentally benign manner is due to the fact that technology is shackled to inadequate anachronistic social structures. He discussed the importance of focusing on personal habits and attitudes as well as knowledge in the development of technological literacy. He stated that most of all technological literacy is the "development and empowerment of a new set of ethical concerns and responsibilities" (p. 190). Such empowerment could become "the best filter we possess against human folly" (Hardin, 1985, p. 2)

In summary, numerous scholars have described technological literacy as a highly complex concept which will be vital to insuring human survival in the future. The concept has evolved from one which basically included developing an understanding of tools and their use, to one that was described by Devore (1991) as focused on a new

vision of the nature and characteristics of technical means in the social order. He envisioned a new widespread technological literacy based on an:

> Enabling ethic grounded in the understanding that technological systems can be designed to be compatible with the living Earth and that the design and development of appropriate technical means will enable human beings to create sustainable quality futures (p. 274).

The Need for Awareness of Technological Impacts on the Environment.

Thirty five years ago Carson (1962) reflected on the history of humans attempting through technology to conquer nature and warned that such a policy held dire implications for our future.

> As man proceeds toward his announced goal of the conquest of nature, he has written a depressing record of destruction, directed not only against the earth's inhabits, but against the life that shares it with him. The history of the recent centuries has it's black passages---the slaughter of the buffalo on the western plains, the massacre of the shorebirds by market gunners, the near extinction of the egrets for their plumage. Now to these and others like them, we area adding a new chapter and a new kind of havoc (p.3).

Carson's examples were of situations where the impacts of technology use could be easily observed. Her predictions of new kinds of havoc include many that unfortunately, are not so readily apparent. Some of these are occurring on a global scale in ways so subtle that they are hard to measure. In an

attempt to provide evidence that the need for adults to develop adequate levels of TEAL is growing increasingly urgent, Durning (1990) thoroughly examined the various documented problems and provided a ranking of the world's "most tenacious and threatening environmental challenges" (p. 40). He concluded that each of these problems was caused by technolgy use. He choose as the one which should be our highest priority, the threat of future climate changes due to " the byproducts of burning massive quantities of fossil fuels" (p. 40). He ranked second the waste disposal crisis and the enormous energy squandered by our throwaway society. Third was the urgent need to adopt better methods of water conservation and protection.

The United States Environmental Protection Agency also convened a panel of the nation's most distingusihed scientists to study the severity of various environmental threats and provide direction toward addressing them. They generally concurred with Durning's rankings which all fall under the broad category of "nonpoint source pollution". However, the panel also included runoff of pesticdes from both farms and lawns. They also ranked as a high priority the destruction of habitat by expanding agricultural use and urban development leading to species extinction and loss of biodiversity (USEPA, 1990). Again, all of the problems identified are caused by technology use.

Others also warned of the urgency of recognizing the extent and the severity of the problems. Malone & Corell (1989) pointed out that "the capacity of the global life-supporting system to sustain a technologically advanced and exponentially expanding civilization is likely to collapse within the forseeable future" (p. 7).

Orr (1992) noted that our knowledge of how to do vast and risky things has far outrun our ability to deal with the consequences of such endeavors. As a result, we have created what he called "monsters of technology" (P. 38) for which no one takes responsibility:

> Whether technology is beyond human control there can be no question, that it is now the preeminent fact in modern societies. Whether it can be controlled and harnessed to the long-term benefit of humanity is *the* question of our civilization (p.39).

Orr reminded us that there is not one single example in history of a society which has been both technologically dynamic and environmentally sustainable.

Hawken (1993) declared that transforming our society into one which employed only sustainable systems of agriculture and development, is the greatest gift that we can give to our children and grandchildren, the gift of a future. He described the value of such a gift as inestimatable. He further explained why he felt that increasing TEAL in individuals can't wait any longer:

> Most global problems cannot be solved globally because they are global symptoms of local problems with roots in reductionist thinking that goes back to the scientific revolution and the beginnings of industrialism. We have operated our world for the past few centuries on the basis that we could manage it if not dominate it, with respect to living systems. We have sacrificed the harmonious development of our cultures for enormous short term gains, and we now face the invoice for that kind of thinking: an ecological as well as a social crisis (p. 201).

Sale (1995) agreed that the term crisis was not too strong to use in describing the present state of our society and each individual's impact on our environment. "Tinkering with that law or regulation, or even stopping that dam or this clear-cut is not going to make any fundamental change necessary. Nothing less than changing the way we live is going to save the planet" (p. A-2).

In summarizing the importance of TEAL, Orr (1992) explained that:

> There are no easy answers to issues posed by technology and when the times comes that we decide to confront some of them, we will find that the widespead technological illiteracy will make it extremely difficult to find acceptable solutions. We have become addicted to technology that locks us into a system (capitalism) and behavior patterns which impose long term costs for short term gains (p. 15).

Horton (Fellenz and Conti, 1990) agreed that we are certainly facing a dilemma and that the process of making changes needs to begin now: