CRITICAL APPRAISAL OF THE SCIENTIFIC AND TECHNOLOGICAL PROGRESS: AN INTERNATIONAL COMPARISON[1]

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Introduction

The contemporary world is characterized by the increasing complexity of its structures, interactions and interdependencies. This tendency gives rise to a number of problems and crisis situations, most of which confront humankind as a whole (Behar, 1990). In this context, science and technology have increasingly propelled and generated current global societal problems. Societal problems of global concern pertain to such matters as the safety of nuclear power plants, the hazards of DNA research and genetic engineering, the increasing gap between the North and the South, the deterioration of the global environment, the destructive capacity of modern weapon systems, the world-wide hunger, the earth's drastic climate changes and other. The international division of labour influences and is influenced by North-South relations which are often determined by technological links and transfers (Gelpi, 1992). Science and technology contribute to new forms of exclusion, both between and within countries (ibid.). All these phenomena gave rise to a new awareness of the social and ethical responsibility of science and technology. This implies that technology is not a collection of neutral devices or machines. As a system, as a science, as a 'manner or style' of thinking about phenomenon, technology is not neutral (Freenberg, 1991; Postman, 1992; Muffoletto, 1996; Bowers, 1988). It is a cultural form which has perceived functions and benefits (Jamison, 1992). Thus, linking science and technology to current global societal issues raises interesting questions, particularly those concerning side-effects over those concerning efficiency and effectiveness. Indeed, the rationalistic progressivism, which sees science and technology as a solution for every global societal problem, cannot be sustained as negative effects often seem to outweigh the positive effects. Global environment and resource issues involving atmospheric pollution, water pollution, the depletion of ozone layer, acid rain, world hunger and poverty, are closely linked with the values integrated in the development and use of technological advances. All these have turned more people

to believe that scientific and technological advances create more problems in society than those they are supposed to solve. In a 1989 Gallup poll (cited in MFA, 1990), 71 percent of the Japanese people rated environmental protection as more important than economic development, a higher percentage than in other countries that were surveyed: the USA (51%), the U.K. (55%), France (52%) and West Germany (61%). Dunlap (1992) also reported that public support for environmental protection is much greater today than it was two decades ago. These attitudes justify the assumption that the resources which sustain life are being destroyed by an increasing world population which tends to use its technology to generate non-sustainable economic development (Baez, 1991). Sustainable development is commonly defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p.8). It is meant to reduce the conflicts that cause environmental degradation by providing a vehicle for integrating the environment and the economy. Seeking sustainability also means redesigning society so that human activities do not have long-term negative impacts on either the environment or the society (Slocombe & van Bers, 1991). As stated by the Asian Development Bank (1990), successful achievement of global equity goals, via growth and economic efficiency, will contradict the environmental dimensions of sustainable development.

The central question addressed by an increasing number of people who are seeking sustainable development is not whether one is for or against technology, but to define the human criteria and priorities that can turn the development and use of technology to human betterment. Adherents to this belief de-emphasise or even reject the deterministic and over-optimistic forms of advanced technologies, and advocate the notions of "human in the centre" and "technology driven by people" (Makrakis, 1988).

Today's society, and certainly that of the 21st century, will place higher demands about scientific and technological issues and their relation to the development of society. These demands also will require development of higher-order cognitive abilities associated with processes of decision making, problem solving and critical thinking. It is thus important to draw special attention to the training of teachers for pre-school to primary and secondary education. These teachers, mostly of which are female, have a decisive role to play on the knowledge and attitudes their students form towards science and technology.

The specific objectives of this study are to examine the influence of political ideology and ecological awareness on perceived attitudes towards science and technology. It is hypothesized that those student-teachers, who place strong em-

phasis on nature and ecological awareness, will be more conscious of the harmful aspects of science and technology. It is also hypothesized that student-teachers who hold more radical ideological and political views will have higher scores on the harmful aspects of science and technology and will be more concerned about environmental issues.

METHOD

Subjects

The study presented here is a part of a larger international and comparative study dealing with global issues in teacher education. Data were collected in five countries, during the 1994/1996 academic years. The survey population consisted of first year and last year student-teachers in Finland, Greece, Holland, Japan and Sweden. The countries were chosen mainly on the basis of cultural contrast; an important factor in comparative and international research. All possible strategies to increase the representativeness of this international and comparative study were adopted. In Japan, the technique of stratified random sampling, was used at the Institutional level on the basis of geographical distribution and the size of the Institution. Through this technique, one-fourth of all Japanese teacher education departments and institutions were sampled. Two-thirds of the Institutions in Finland, Greece and Sweden and half of the Institutions in Holland, representing all geographical areas, were sampled. Altogether, 53 university Institutions were included: seven from Finland, six from Greece, twenty from Holland, nine from Japan and eleven from Sweden. In each Institution, the survey instrument was distributed to one, two or more course classes, depending on the size of the class and the structure of the Institution. Only student-teachers from the first year and the last year of the study were included in the survey. In total, 3080 student-teachers answered the questionnaire: 381 from Finland, 358 from Greece, 792 from Sweden, 1056 from Japan and 493 from Holland. The findings of this study can be generalised from all five countries, as the Institutions represent all geographical regions in each country. However, we must be cautious, since the achieved sample does not represent a pure probability-based sample.

Instrumentation and Data Analysis

A closed-end survey instrument, developed for this comparative study, was used to collect the data. It consisted of six sections, namely: (1) demographic data, (2) foreign language proficiency, (3) level of importance of school subjects, (4) mass

media and non-media global content consumption, (5) behavior/action towards issues of global concern, (6) attitudes towards global education issues (global-mindedness), and (7) knowledge of global issues.

The major scale of measuring attitudes towards the impact of science and technology was constructed on the basis of 14 items. The items of this scale were worded negatively so that higher values indicate that students hold more negative values about the harmful aspects of science and technology. The reliability analysis supported the inclusion of all the items in the measurement model of the harmful aspects of science and technology with a very high reliability ALPHA coefficient equal to 0.88 (Table 1). The other major scale of measuring concern on environmental issues was constructed on the basis of eight items. Negatively worded items were recoded so that higher values indicate that students have increased levels of environmental consciousness. The reliability analysis of the items indicated an ALPHA coefficient equal to 0.64, enough to be accepted as a reliable scale (Table 2). Political ideology was measured by a single variable on a five-point scale, indicating 1 more conservative and 5 more radical. Data analysis included univariate statistics, oneway analysis of variance and multiple comparison Duncan tests.

TABLE 1. *Reliability of Items in the Science and Technology Scale*

Items	Alpha if item deleted
Scientific progress has increased tensions between nations.	0.87
Much of the anxiety in modern society is due to scientific development.	0.87
Scientific advances do more harm than good.	0.86
Science has ruined the environment.	0.86
Science is the cause of many of the world's problems.	0.86
We cannot keep counting on science to solve mankind's problems.	0.88
Scientific progress has made our world too complicated.	0.86

Technological progress has increased tensions between nations.	0.87
Much of the anxiety in modern society is due to technological development.	0.86
Technological advances do more harm than good.	0.87
Technology has ruined the environment.	0.87
Technology is the cause of many of the world's problems.	0.87
We cannot keep counting on technology to solve mankind's problems.	0.88
Technological progress has made our world too complicated.	0.86
Note: Cronbach's alpha= 0.88; number of cases=3080 number of items= 14.	

TABLE 2. *Reliability of Items in the Environmental Consciousness Scale*

Items	**Alpha if item deleted**
People should not worry about turning out lights in a hotel room because the cost is included in their bill.	0.62
Mankind was created to rule over nature.	0.64
Environmental pollution constitutes a specific form of violence.	0.61
More emphasis should be placed on teaching children about nature than about technology.	0.64
If we want to prevent environmental destruction, we have to alter affluent life-styles and eliminate overconsumption.	0.59
Despite the fact that personal cars give us a sense of freedom and comfort, public transportation should be used whenever possible for energy conservation.	0.59

Our country's industrial and material gains cannot be justified if they come at the expense of the environment.	0.59
Reducing pollution and environmental damage is more important than increasing our living standards.	0.57
Note: Cronbach's alpha= 0.64; number of cases= 3080 number of items= 8.	

Results

Although, the level of concern on environmental issues was high among student-teachers across the five countries, Scandinavian student-teachers (Finnish and Swedish) scored higher than any other country group. An environmentalist consciousness has certainly emerged in Sweden and, in many respects, environmentalism has been a more significant political force in Sweden than it has been in many other countries (Jamison et al., 1990). As could be expected in a country that served as a model welfare state, there has been a strong concern about environmental issues on the part of the state. This strong state interest in environmental issues was compounded in the Swedish case by an early 'ideological' incorporation of environmentalism on the part of the established political parties, especially those of the social democratic party, representing the interests of the old social movement of the working class and the agrarian Centre party, representing the interests of the farmers. In the case of the Netherlands, public concern for environmental issues grew quickly, reaching its culmination in the early 1970s. Influenced by the growing environmental concerns of the public at large, Dutch political parties also began to take up environmental issues as a major political problem in the early 1970s. No party would now deny the importance of these issues (Jamison et al., 1990). On average, student teachers' political beliefs are placed on centre and moderate radical lines, with Dutch student teachers to exhibit more radical political beliefs than the other country groups (Table 3).

Finnish, Dutch and Swedish student teachers are identified within the "undecided or uncertain" category of the science and technology scale (Table 3). The category "Uncertain" most probably implies a shaded and two-sided position and not an ignorant attitude. Indeed, issues of global concern anchored in scientific and technological applications to society, often involve trade-offs between conflicting values in which there is no clear view of right or wrong. It is obvious that a

nuclear holocaust would have a devastating effect on the world's environment, but at the same time, nuclear power sustains the economies of most industrialized and developing countries. .

TABLE 3. *Subject Types According to Environmental Consciousness, Politico-ideological Beliefs and Scientific-technological Beliefs.*

Environmental Consciousness	Political Beliefs	Science-Tech Beliefs					
Students' Country	**Total No**	**Mean Type[d]**	**Mean Type[e]**	**Mean Type[f]**	**Rating[a]**	**Rating[b]**	**Rating[c]**
FINLAND	381	4.06	proenv	3.16	radic	2.92	uncer
GREECE	358	3.84	proenv	3.00	cent	3.30	pess
HOLLAND	493	3.84	proenv	3.30	radic	3.03	uncer
JAPAN	1056	3.84	proenv	2.92	cent	3.30	pess
SWEDEN	792	4.34	proenv	3.10	cent	2.98	uncer

[a] *Mean rating on a 5-point scale where 1= strongly disagree and 5= strongly agree.*

[b] *Mean rating on a 5-point scale where 1= more conservative and 5= more radical.*

[c] *Mean rating on a 5-point scale where 1= strongly disagree and 5= strongly agree.*

[d] *Subjects considered pro-environmental (proenv) when mean rating >3.1, anti-environmental (antenv) <2.9 and uncertain (uncer) between 2.9 and 3.1.*

[e] *Subjects considered radical (radic) when mean rating >3.1, conservative (conserv) <2.9 and center between 2.9 and 3.1.*

[f] *Subjects considered optimists (optim) when mean rating <2.9, pessimists (pess) >3.1 and uncertain (uncer) between 2.9 and 3.1.*

The statistically significant differences identified by the multiple comparison Duncan test verify the hypothesis that respondents who are more concerned about environmental issues have more negative or pessimistic attitudes towards the impact of science and technology on society (Table 4). Similarly, it has been revealed that student-teachers who have more radical political values are more concerned about environmental issues (Table 5). Also, those students from the Swedish and Dutch sample, who have radical political values, have expressed more pessimistic attitudes of the impact of science and technology on society (Table 6). Among Greek student-teachers, however, those who belong in the two extremes of the political beliefs scale scored higher on the pessimistic side of the scale related to the impact of science and technology on society.

TABLE 4. *Multiple Comparison Duncan Test of Scientific-Technological Beliefs by Environmental Consciousness*

FINLAND					GREECE				
Mean		Envir. Consc. Scale			Mean	Envir. Consc. Scale			
Soc-Tech	2	3	4	5	Soc-Tech	2	3	4	5
2.35	2				2.96	2			
2.80	3				3.26	3			
3.00	4	*	*		3.36	4	*		
3.40	5	*			3.38	5			
HOLLAND					JAPAN				
Mean		Envir. Consc. Scale			Mean	Envir. Consc. Scale			
Soc-Tech	2	3	4	5	Soc-Tech	2	1	3	4	5
2.57	2				2.87	2				
2.93	3	*			3.21	1				
3.19	4	*	*		3.24	3	*			
2.93	5	*	*	*	3.44	4	*	*		
4.10	5	*	*	*						
SWEDEN										
Mean		Envir. Consc. Scale								
Soc-Tech	2	3	4	5						
2.75	2									
2.75	3									
3.01	4	*								
3.35	5	*	*							

Note: (*) Denotes pairs of groups significantly different at the P<0.50 level

TABLE 5. *Multiple Comparison Duncan Test of Environmental Consciousness by Political Beliefs.*

GREECE						HOLLAND					
Mean	Political Beliefs Scale					Mean	Political Beliefs Scale				
Envi-Cons	1	2	3	4	5	Envi-Cons	1	2	3	4	5
3.73	1					3.55	1				
3.82	2					3.75	2				
3.84	3					3.75	3				
3.91	4					3.96	4		*	*	
4.17	5	*				4.29	5	*	*	*	*
JAPAN						SWEDEN					
Mean	Political Beliefs Scale					Mean	Political Beliefs Scale				
Envi-Cons	1	2	3	4	5	Envi-Cons	1	2	3	4	5
3.75	1					4.07	1				
3.80	2					4.21	2				
3.85	3					4.34	3	*	*		
3.85	4					4.52	4	*	*	*	
4.16	5	*	*	*	*	4.46	5	*	*	*	*

Note: (*) Denotes pairs of groups significantly different at the P<0.50 level

Finnish sample does not denote pairs of groups significantly different at the P<0.50 level

TABLE 6. *Multiple Comparison Duncan Test of Scientific-Technological Beliefs by Political Beliefs.*

SWEDEN						GREECE					
Mean	Political Beliefs Scale					Mean	Political Beliefs Scale				
Soc-Tech	1	2	3	4	5	Soc-Tech	1	2	3	4	5
2.69	1					2.98	2				
2.82	2					3.08	4				
2.99	5					2.66	3	*			
3.01	4	*	*			3.30	5				
3.11	3	*	*			3.50	1	*	*	*	
HOLLAND											
Mean	Political Beliefs Scale										
Soc-Tech	2	3	4	5							
2.57	2										
2.93	3	*									
3.19	4	*	*								
4.71	5	*	*	*							
Note: (*) Denotes pairs of groups significantly different at the P<0.50 level											
Finnish and Japanese samples do not denote pairs of groups significantly different at the P<0.50 level											

Discussion

This study shows that student-teachers' political beliefs and concern about environmental issues play an important role in their attitudes towards the impact of science and technology on society. An understanding of the principles of ecology, science and technology and an adoption of an environmental ethic seems to be very crucial today. At the same time, Finnish, Dutch and Swedish student teachers are identified within the 'undecided or uncertain' category of the science and technology scale. As pointed earlier, this most probably implies a shaded and two-sided position and -at worst- an ignorant attitude. What are the implications of these findings in education? How should the scientific and technological cur-

riculum be structured and its teaching be organized so as to give insights into the environmental and multi-faced impact of technology in modern society and instill in young people a feeling of global consciousness? People should be given the opportunity to reflect on the way organizational, economic and social structures are shaped by technological innovations and to know something about the driving mechanisms behind those innovations. Efforts to promote global societal issues related to science and technology in elementary and secondary schools will not succeed unless educators know what education on science and technology related to global societal issues is, why it is an important part of education in the school curriculum and how to include such a perspective in the curriculum. The teaching of science and technology should be carried out in a more 'contextual' way pointing out that technology and science are not neutral. Consistent with this is the notion that every school subject can deal with a certain set of real-world events, rather than in a decontextualized form. This links, for example, the learning of science and technology with certain content related to real-life and socially-oriented issues. This presupposes that more attention will be paid to the elements of 'science ethics' and 'technology assessment' appealing to values and to a normative approach, in contrast to the positivism that has prevailed so far. Ability to connect information and ideas, within and between academic disciplines, and to link different fields of knowledge is a key to high-level understanding of social reality. Education for responsible and competent citizenship in an increasingly complex technological society requires that students be able to synthesize and apply knowledge from many disciplines. All knowledge must be integrated and treated in a holistic way. The holistic dimension marks a shift from the Newtonian and Cartesian paradigms in which the mind is separated from matter, the rational from the spiritual, the emotional and the intuitive, the subject from the object and the human being from the natural world (Capra, 1989;1983). A growing number of social thinkers attribute the many global ecological and social crises we are now facing, to the pervasiveness of this fragmentalistic thinking (Greig et al., 1989). A holistic dimension to the global curriculum rejects fragmentalism and replaces compartmentalisation to a biocentric egalitarianism that establishes the connection of knowledge and the empowerment and emancipation of learners. A holistic thinking, in other words, is integrative in nature and supports the unity of matter, mind and knowledge and the unity of the rational, affective, social, physical, emotional/spiritual, aesthetic and cognitive dispositions. As such, every discipline in the social studies can be basically connected to content on science and technology in society. To ignore this reality will limit students' abilities to comprehend their world and to act effectively within it.

NOTE

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