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SCIENTIFIC AND TECHNOLOGICAL PROGRESS, POLITICAL BELIEFS AND ENVIRONMENTAL SUSTAINABILITY

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Abstract

With the development of science and technology, a basically optimistic ideology of progress has emerged. This deterministic attitude has been challenged in recent decades as a result of harmful side-effects generated by the way technology and science have been approached and used. The study presented here is a part of a larger international and comparative study dealing with global/environmental issues related to political orientation, science and technology. 3 080 pre-service teachers from Finland, Greece, Sweden, Japan and Holland answered a closed-end survey instrument. The results of this study show that none of the sample country respondents identified themselves as optimists concerning the impact of science and technology on society and environment. The no-stance and the pessimistic attitudes towards technology and science seem to derive from the human and environmental costs associated with science and technology development. A strong connection was found between environmental consciousness and attitudes towards the role and impact of science and technology on society. These results indicate that society and education, in particular, should place higher critical concerns about scientific and technological issues and their relation to the development of a sustainable society.

Key words: *science, technology, political beliefs, environmental sustainability*

Introduction

In the latter half of the 20th century, we witnessed a growing awareness of an ecological crisis and depletion of the natural resources. With the coming of the new millennium, it is imperative to take into serious consideration the 1987 report of the World Commission on Environment and Development (WCED) for increasing consciousness and action towards sustainable development. The report defined sustainable development as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 8). However, the Brundtland definition raises a number of questions, such as: *How does one define 'needs' as opposed to 'wants' in different contexts?* The intergenerational approach of sustainable development should be appreciated, but we cannot know what future needs exist or how needs are evaluated, and we cannot know how today's actions are valued one generation later (Lippert, 2004). Despite the simplicity, ambiguity and broadness of the

Brundtland definition, it has generated hundreds of other definitions and popularised the quest for sustainable development. The emergent definitions usually reflect a range of discourses in sustainability that are often related to the concepts of 'weak' versus 'strong' sustainability or 'shallow' versus 'deep' sustainability. 'Shallow' or 'weak' sustainability is often associated with neo-liberal approaches to the economic growth model, while strong and deep sustainability is often associated with deep ecology. The basic notion of weak/shallow sustainability is that it conceptualises the non-human world not in biophysical terms but in terms of its economic value (Hediger, 2004; Dietz & Neumayer, 2007) in contrast to strong/deep sustainability which sees the triptych of environmental integrity, social/economic equity/justice and the well-being of human and non-human world as a whole.

The concept of sustainable development is also often associated with the strong ties forged between science and technology. The word 'technology' encompasses essentially three meanings: 1) *tools and instruments* to enhance human ability to shape nature and solve problems; 2) *knowledge* of how to create things or how to solve problems and 3) *culture* related to our understanding of the world, our value systems (Vergragt, 2006). In contrast to technology, science is seen as a system of acquiring knowledge, deductively and/or inductively using various methodologies. Current perceptions of science and technology see them both as inter-dependent and not linear. Indeed, the boundaries between modern science and technology have become blurred and technology as a system, as a science, as a 'manner or style' of thinking is not neutral (Muffoletto, 1996; Breschi & Catalini, 2009). It is seen as a cultural form which has perceived functions and benefits (Lederberg, 1997; Klein & Kleinman, 2002; Bissell, 2010). The ways in which a technology is used cannot be understood without understanding how that technology is embedded in its social context (Nye, 1997; Bissell, 2010).

Looking into the literature, a deep-ranging *ambivalence* of the roles of technology in regard to sustainable development can be observed. On the one hand, technology is regarded as a *problem* for sustainability and as a cause of environmental degradation, but, on the other hand, it is also considered as a *solution* of sustainability problems (Vergragt, 2006; Grunwald, 2009, 2012). It is argued that, while scientific knowledge has led to remarkable advances that have been of great benefit to humankind, at the same time, applications of scientific advances have led to social imbalances, economic disparities, climate change and environmental degradation (Hassan, 2001). World-wide experiences indicate that environmentally sustainable economic growth is difficult to be achieved if development is approached only in capital terms (Goodland, Daly, El Serafy, & von Droste, 1991; Bhaskar & Glyn, 1995; Makrakis, 2012). There are increasing concerns that natural resources are being destroyed by an increasing world population which tends to use its technology to generate non-sustainable economic development. As a reaction to deterministic beliefs, more people tend to believe that scientific and technological advances create more problems in society than those they are supposed to solve (Vergragt, 2006). Indeed, most of the pessimistic notions concerning science and technology have focused upon its human and environmental costs while the optimistic ones are anchored in the notions of technological determinism and instrumentalism. It seems that the rationalistic progressivism which sees science and technology as a solution for every global societal problem cannot be sustained as positive effects often seem to coexist with the negative effects. In this sense, the long-term protection of the environment is, therefore, not primarily a technical problem but rather a social and moral problem

that can only be solved by drastically reducing the strong influence of materialistic values (Huesemann, 2001).

In general, environmental values are expected to influence profoundly the way people think about their relation to the earth. Schultz's (2000) study showed that empathising with nature increases people's awareness of their interconnectness with nature, thereby increasing the saliency of biospheric values. It has been noticed that environmental consciousness is growing at a rapid pace, and research findings substantiate a widespread acceptance of various versions of environmentalism (Dunlap & Scarce, 1991; Dunlap, 1992, 1995; Mass, 2006). The concept of environmental consciousness used here refers to specific psychological factors related to individuals' propensity to engage in pro-environmental behaviours, incorporating also other factors or psychological constructs that are habitually associated to them, such as beliefs, values, attitudes, knowledge (Kormos-Koch, 2007; Sįnchez & Lafuente, 2010). Aoyagi-Usui, Vinken and Kuribayashi (2003) found that the structure of environmental values in Asian countries differ from those in Western countries. They have reported that in the Netherlands and the United States of America (the USA), environmental values were linked with altruistic values that are perceived as being contrary to traditional values. In Japan, Thailand and Philippines, environmental values were linked with both traditional and altruistic values.

In spite of worldwide popularity and well-reasoned calls to action, there is a large gap between environmental attitude and behaviour worldwide (De Oliver, 1999; Yamada, 2008). It has also been found that information, knowledge, concern and awareness can predict little of the variability in most forms of environmental behaviour (Ryland, 2000). Numerous studies show that the existence of people's environmental concerns, and their intentions for taking environmental actions remain descriptive since these did not link to actual behaviours (Economic Commission for Latin America and the Caribbean [ECLAC], 2000). The expected correlations between support for the new environmental paradigm, distrust of science and technology, post-material values and concern for environmental conditions were found to be partially supported by the results of a Swedish study (Gooch, 1995).

Research has been also directed towards examining the relation between environmentalist commitments and political orientations. Studies have found a positive relation between environmental concern/values and left/liberal politics (Salazar & Alper, 2002). In the USA, for instance, people who support Democrats and Liberals are more concerned about environmental quality than those who support Republican and Conservative counterparts (ECLAC, 2000). A similar trend also exists in Great Britain where the right-wing Tory, Conservative Party, is placing a less importance to environmental issues than left wing Labour and Liberal Democrats (ibid.). It is generally perceived that pro-environmental values may cohere with environmentalists' political ideas, although some have argued that environmentalism is independent of the left/right ideology. In this sense, the prevalence of environmentalism may be compatible with varying political ideological orientations, although those who support more radical political standpoints would seem to express higher environmental consciousness. It has been found that the relationship between a conservative political orientation and a strong environmental concern is positive while the relationship between this political orientation and membership in an environmental organisation is negative (Skogen & Strandbu, 2000). However, the more comprehensive critical stance found in environmental organisations is still related to a radical political ideology (ibid.). Therefore, political ideology may not be

necessarily a pre-requisite for being environmentally concerned, and differences in cultural and historical context must be taken into consideration in relating political ideology to environmental concerns.

An understanding of the principles of ecology, science and technology and an adoption of an environmental ethic seems to be very crucial today. The reason why the connection of science and technology with environmental sustainability is so important today is that humanity is entering a critical era in which teacher education is expected to play a critical role (Nicolaides, 2006). Basic to education for sustainable development efforts is the production of an informed citizenry capable of making crucial decisions about current problems and issues and taking personal actions as a result of these decisions. Previous research shows that a remarkable amount of courses offered in teacher training do not fully consider the demands of an integrative thinking, neither the ecological, economic and social aspects of education for sustainable development (Henze, 2000; Makrakis, 2012). There is thus need to transform teacher education towards education for sustainability (Down, 2006; Makrakis, 2006) which can provide a normative framework for educational innovation and research (Posch & Steiner, 2006). The research presented in this paper constitutes a part of an international and comparative study that aimed to explore global/sustainability issues in teacher education. In particular, the study described here aimed to examine the influence of political orientation and environmental consciousness on perceived attitudes towards science and technology. It was hypothesised that

- pre-service teachers who place strong emphasis on nature and ecological awareness will be more conscious of the harmful aspects of science and technology;
- pre-service teachers who hold more radical ideological and political views will exhibit higher environmental consciousness than those who hold more conservative political views.

Method

Subjects

The survey population consisted of first year and last year pre-service 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 teacher education institutions in Finland, Greece and Sweden and half of the institutions in Holland, representing all geographical areas, made up the final sample. 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. In total, 3 080 pre-service teachers answered the questionnaire: 381 from Finland, 358 from Greece, 792 from Sweden, 1 056 from Japan and 493 from Holland.

Instrumentation and data analysis

A closed-end survey instrument developed for this comparative study was used to collect the data. In this part of the study, only variables pertaining to the hypotheses addressed are included, that is: a) political orientation; b) environmental consciousness and c) attitudes towards science and technology. Political orientation was measured by a single variable on a five-point scale, indicating one more conservative and five more radical. The other major scale of measuring concern on environmental issues was constructed on the basis of eight items. Some of the items included in the environmental consciousness scale were of the type that: people should not worry about turning the lights in a hotel room because the cost is included in their bill, humankind was created to rule over nature, environmental pollution constitutes a specific form of violence, reducing pollution and environmental damage is more important than increasing our living standards, our country's industrial and material gains cannot be justified if they come at the expense of the environment and so on. The reliability analysis of the items indicated a Cronbach's alpha reliability coefficient equal to 0.64, enough to be accepted as a reliable scale. The scale of measuring attitudes towards the impact of science and technology was constructed on the basis of 14 items. These items included notions that scientific and technological progress has increased tensions between nations, that much of the anxiety in modern society is due to scientific and technological development, that scientific and technological advances do more harm than good, that science and technology is the cause of many of the world's problems and so on. The reliability analysis supported the inclusion of all the items in the measurement model of the science and technology construct with a very high Cronbach's alpha reliability coefficient equal to 0.88. Data analysis included univariate statistics, one-way ANOVA and multiple comparison Duncan tests.

Results

Indicators of main examined variables

Descriptive statistical analysis indicated that the level of concern for environmental issues was high among pre-service teachers across the five countries ranging from 3.8 to 4.3 on the five-point scale (Table 1). It was revealed that Scandinavian pre-service teachers (Finnish and Swedish) scored higher than other country groups, with a significance level at $p < 0.01$. These results denote a positive attitude towards the need for environmental sustainability.

While environmental consciousness seems to be well established across all the countries examined, the data analysis showed that none of the country samples exhibited optimistic views concerning the impact of science and technology on society. More specifically, Finnish, Dutch and Swedish pre-service teachers are identified within the 'undecided or uncertain' category (mean rate between 2.9 and 3.1) of the science and technology scale (Table 1). The category 'Uncertain' most probably implies a shaded and two-sided position and not necessarily an ignorant attitude. Indeed, issues of environmental concern related to scientific and technological applications often involve trade-offs between conflicting values in which there is no clear view of positive or negative. Interestingly, Greek and Japanese pre-service teachers have clearly discerned

a pessimistic attitude towards science and technology (mean rating less than 2.9). In terms of political orientation, on average, pre-service teachers are placed on centre and moderate radical lines.

Table 1. Subject types according to environmental consciousness, political orientation and attitudes towards science and technology

Pre-service teachers' country	Total number	Environmental consciousness		Political orientation		Science-technology attitudes	
		Mean rating[a]	Type[d]	Mean rating[b]	Type[e]	Mean rating[c]	Type[f]
Finland	381	4.1	Proenv	3.2	Radical	2.9	Uncertain
Greece	358	3.8	Proenv	3.0	Center	3.3	Pessimist
Holland	493	3.8	Proenv	3.3	Radical	3.0	Uncertain
Japan	1056	3.8	Proenv	2.9	Center	3.3	Pessimist
Sweden	792	4.3	Proenv	3.1	Center	3.0	Uncertain

[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.

Multiple comparison analysis

With the development of science and technology, a basically optimistic ideology of progress had emerged, which saw science and its applications as the pre-eminent tool of culture that could solve many global problems facing humanity. This contradicts with the serious concern expressed about the global consequences of human activity and in the way scientific and technological advances are used. As it has been pointed in the introduction, those who exhibit pro-environmental consciousness and actions usually hold anti-science/technology attitudes, arguing that science and technology have been used to serve the interests of anti-environmentalists. The multiple comparison analysis showed that respondents who were more concerned with environmental issues had expressed more negative or pessimistic attitudes towards the impact of science and technology on society and environment (Table 2). It has been also revealed that pre-service teachers who had more radical political views were found to be more concerned about environmental issues (Table 3).

Table 2. Multiple comparison Duncan test of science-technology attitudes 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	*				
4.71	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

It has been also revealed that pre-service teachers who had more radical political views were found to be more concerned about environmental issues (Table 3).

Table 3. Multiple comparison Duncan test of environmental consciousness by political orientation

GREECE							HOLLAND						
Mean		Political Beliefs Scale					Mean		Political Beliefs Scale				
Envi-Cons		1	3	2	4	5	Envi-Cons		1	2	3	4	5
3.73	1						3.55	1					
3.82	3						3.75	2					
3.84	2						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

Discussion

It has been argued here that a clear understanding of the principles of ecology, science and technology and an adoption of an environmental ethic seems to be very crucial today. The results of this international and comparative study focusing on pre-service teachers' perceptions of the impact of political orientation and attitudes towards science and technology as well as on environmental consciousness do not sustain the belief that science and technology can provide effective solutions to many environmental problems.

An instrumental and deterministic attitude towards science and technology has been challenged in recent decades as a result of harmful side-effects generated by the way science and technology have been approached and used. None of the sample country respondents identified themselves as optimists concerning the impact of science and technology on society and the environment. The no-stance or the pessimistic attitudes towards science and technology seem to derive from the human and environmental costs attributed to the instrumental use of scientific and technological development. The results verify the hypothesis stated that there is close connection between environmental consciousness and attitudes towards the role and impact of science and technology on society and environment. In other words, the higher the degree of respondents' environmental consciousness, the more pessimistic stance on science and technology. It has also been verified that those who identify themselves more in the radical political spectrum hold less optimistic attitudes to science and technology and their vision of ecological degradation is becoming increasingly prominent. It is also worth pointing out that Scandinavian pre-service teachers were found to be more sensitised to environmental sustainability principles and ethics than pre-service teachers from other European countries and especially from Japan. As it could be expected in a region whose countries served as model welfare states, there has been a strong concern with environmental issues on the part of the state. This strong state/regional 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 green and the social democratic party. In general, the perceived environmental sustainability principles and ethics among all the pre-service teachers representing the selected European countries and Japan have shown increased environmental concern.

What are the implications of these findings in teacher education? How should the science and technology curriculum be structured and its teaching organised so as to give insights into the environmental and multi-faced impact of science and technology in modern society? How should we instil in young people a feeling of global and environmental consciousness? Efforts to promote global environmental sustainability 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 and environmental issues is, why it is an important part of education in the school curriculum and how to integrate such a perspective in the curriculum. The results of the present study show the need to develop a critical and constructive attitude towards science and technology. Also, in addition to practice on specific science and technology skills, class activities should integrate one or more objectives related to global societal and environmental concerns. Since sustainable development education draws upon many disciplines, an interdisciplinary approach seems to be needed, focusing on the interrelation between social, ecological, environmental and cultural aspects of sustainability (Dale &

Newman, 2006; Makrakis, Gkotzos, & Larios, 2012; Makrakis, Larios, & Kaliantzi, 2012). Such an inter/trans-disciplinary perspective is very critical in approaching science and technology in school education, especially in their connection to sustainability.

The argument for emphasising a global/sustainability education perspective in dealing with science and technology is based on a primary goal of elementary and secondary schools – education for responsible citizenship. Education for responsible and co-responsible citizenship in an increasingly complex technological society requires that students be able to synthesise and apply knowledge from many disciplines. Techno-sciences can, and should, serve as vehicles for a sustainable future and global understanding, especially through using web-based technologies (Makrakis, 2010). It has been found, however, that the potential of using techno-science as languages that can convey meaning and evoke emotions which could raise learners' social consciousness and social responsibility is ignored (Makrakis & Kostoulas-Makrakis, 2005). If current patterns of attitudes towards science and technology persist and if ecological sustainability is an appropriate vision of the future, there is a need for a move towards an alternative curriculum and teaching/learning paradigm. Current international research indicates that teaching and learning approaches such as placed-based learning, which is the most relevant with education for sustainable development pedagogy, along with inquiry-based learning and problem/project-based learning are the least used in higher education teaching, even in teacher education (Makrakis, 2012). The ethical issues behind science and technology should also be amalgamated with the thesis that teaching and learning is an ethical and political praxis. As Holland, Mulcahy, Besong and Judge (2012) state, "the ethical-values bases of learners and educators effectively filter the way in which the cognitive experience is created and the manner in which the individual learner makes sense and/or constructs meaning within the learning environment" (p. 40). Critical and reflective thinking is acknowledged as one of the key skills and processes in the field of education for sustainability. Kostoulas-Makrakis' (2010) model on transformative learning towards sustainability uses critical reflection at the epicentre of such a process. Participants get engaged in discourse and critical self-reflection, using various activating events and disorienting dilemmas, through which they come to critically examine their personal views and, therefore, open themselves to alternative views and practices (Dovros & Makrakis, 2012). A detailed comprehensive response to this is well beyond the scope of this paper, but the results of this survey suggest that critical education for sustainable development is needed. This implies that the objectives should focus on critical consciousness and the development of appropriate competence and skills related to social and environmental action.

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