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A Comparison of the Attitudes of Spanish and American Secondary Science Teachers Toward Global Science and Technology Based Problems / Threats

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Abstract: In this study, Spanish and US secondary science teacher data is used to address the relationship between what science teachers teach and the science and technology based environmental problems / threats faced by the world. The results of a two part questionnaire indicated that teachers of both countries are worried about the problem of pollution of the planet. The US teachers showed greater sensitivity to the problems related to sustainable development and the limited resources of the planet. The Spanish were more concerned about problems regarding unjust distribution of the natural resources and possible ways to equitably distribute them. However, the majority of both teacher groups recognized that they do not dedicate much time to the treatment of these subjects in class.

Key words: Global Science, Technology, Problems, Threats

INTRODUCTION

In the United States and other developed countries, there continues to be disagreement over what it means to be science literate and what the scientifically literate person should know, value and do as a citizen (Enger and Smith, 2003; Bybee, 1997). Most US and Spanish science educators seem to agree that teachers should orient school science programs around the knowledge, values and skills required for technological and scientific careers, but does this knowledge necessarily lead to science literacy in students who will not pursue careers in science, technology, engineering and mathematics (STEM)? Moreover, do science teachers also think that an important reason for teaching science is to develop science and technological literacy in students if that knowledge will help them understand science based environmental problems / threats and become better able to address these problems as voting citizens?

In the US, the relatively recent federal government mandated act, No Child Left Behind (NCLB), (PL 107-110, 2001) in conjunction with individual state standards, mandated that all high school graduates take and pass an exit exam in basic science to graduate from high school starting in 2008. National (NRC, 1996) and state science standards will provide the guidelines for the essential science knowledge base for the questions that will be in these exit exams. Likewise, the educational reform proposed in Spain in the 90's, is more in tune with advances in educational research with the goal of eliminating discriminating barriers within the school population at the age of 14. As a result, it extends compulsory education to the age of 16 and lists among the priorities of secondary scientific scientific and technological literacy of pupils (Membiela, 1997). These new guidelines call into question the exclusive preparation for further study function of science instruction in secondary education.

Science education, and in particular scientific literacy for all, has become an urgent demand according to the general opinion of both experts and politicians. The need to teach science to all students, including students pursuing STEM careers, implies an aim of making compulsory secondary education students understand the contribution science has made and still makes to the evolution of our society (rationalism, communication, agriculture, energy, medicines, new materials, machines, etc.), thus starting the analysis of the complex interactions among science, technology and society (Solbes & Vilches, 1997). Another objective listed by the authors is that of science teachers getting to know the problems derived from the unplanned consequences of technology: air-pollution, global warming, using up energy resources, etc. so as to foster respect and care for the environment as well as rational management and use of existing resources. The assumption can be made that if science teachers are well versed in the environmental problems / threats and have an understanding of the basic science and technology they are based on, those teachers will be more likely to transfer that understanding to their students.

In addition to the importance of more knowledge in basic science and technology, we can also ask what part the world view a student develops when he or she grows up in a particular culture, has on his / her attitudes about

Table 1. Personal data of the secondary Spanish teachers

Gender	Age	Nationality	Hi Degree	Major	CouTaught	Grade Tau
Male- 39	26-30, 7	Span. 89	MA- 89	Bio- 28	Bio- 25	7 – 7
Fem- 50	31-35, 12		PHD- 3	Chem- 37	Chem-28	8 – 11
	36-40, 18			Phys- 18	Phys- 32	9 – 43
	41-45, 36			Geo- 6	EarSci- 6	10 – 46
	46-50, 12			Engi- 3	Gsci- 80	11 – 71
	51-55, 4					12 – 66
	56-60, 0					

environmental problems/threats. The preconceived notions of Americans regarding how Iraqi citizens would react to being invaded in 2003 by the US and UK clearly indicates that the world view different cultures have toward democracy is very different. Is this true in science and technology based environmental problems/threats as well? This paper will use data from Spanish and US secondary science teachers to address the relationship between what science teachers teach and the recognized science and technology based environmental problems/threats faced by the world.

Method

Subjects

The subjects were two groups of secondary teachers from Spain and the United States. A personal data form was filled out by all teachers that identified them by gender, age, nationality, highest degree held, area of study, courses taught, grade level taught, teaching location and the number of students taught per day.

89 Spanish teachers from three different areas of Spain (Basque Country, 48; Alicante, 19; Santander, 22) completed the questionnaire. The personal data requested their age and gender (39 males and 50 females). All teachers were Spanish and all had a Masters degree in the area of science or engineering since this is the minimum degree level required to teach in secondary education in Spain. General science (physics, chemistry and biology) was the most frequently taught subject because it is obligatory in grades 7, 8, 9 and 10 in the Spanish curriculum in secondary education and the majority of subjects were grades 9-12 teachers. The 89 teachers taught an average of 82 students per day with a class size range of 20-32 (see Table 1).

The US group had 42 teachers, all from a western state. 22 were females and 18 were males and the average age was around 45. All but two were US citizens. The most common major was biology but seven teachers had majors in areas besides the main sciences including elementary education, library science, health, psychology, electronics, computer technology, geography and civil engineering. General science, physical science and life science were the most often taught sciences. The 42 teachers taught an average of 122 students per day with a size range of 20-190. The teachers with small numbers of students taught in Charter schools within the public system. The majority of teachers taught in grades 9-12, high school (see Table 2).

Research Questions

The data from secondary science teachers in Spain and the US was used to gain more information about the following two general ideas: First, the relationship between the science content taught by science teachers that includes or does not include the environmental and

Table 2. Personal data of the secondary United States teachers.

Gender	Age	Nationality	HiDegree	Major	CouTaught	GradeTau
Male-18	26-30, 4	Am. – 40	BA – 2	Bio – 19	Bio – 10	7- 12
Fem-24	31-35, 7	Other -2	BS -8	Chem – 2	Chem – 9	8- 14
	36-40, 4		MA – 3	Physics-1	Physics -6	9 – 21
	41-45, 7		MS – 18	Geo – 4	EarSci -2	10 – 29
	46-50, 12		MEd – 8	GenSci -7	EnvSci-7	11 – 29
	51-55, 7		MBA – 1	PhySci -3	GSci – 24	12 – 29
	56-60, 1		PhD – 2	Math-2	LifeSci-12	
				Hydro-2	PhySci-16	
				Other-7		

Key: HiDegree, highest degree; CouTaught, courses taught; GradeTau, grade taught; Bio, biology; Chem. Chemistry; Geo, geology; Gen Sci, general science; Phy Sci, physical science; Math, mathematics; Hydro, hydrology; EarSci, earth science; EnvSci, environmental science;

technological problems/threats and challenges that, in their opinion, humanity faces now and will face in the near future; and Second, the priorities given by the Spanish and US secondary science teachers toward eight science and technology driven global environmental problems/threats that affect humanity and other life on earth (Brow, 1997; Bybee, 1994, 1986; Gil et al., 1998; Selbes et al., 1997).

The above two general ideas are specifically addressed by the following six questions:

1. What problems/threats that relate to global technology and the environment do you teach your students about in your science classes?
2. What were some of the environmental and technological problems that were discussed in the 2002 Johannesburg Earth Summit?
3. Can you describe any reasons why you do or do not teach about environmental and technological problems and or threats in your science classes?
4. How much coverage do you give to technological and environmental problems/threats in your science classes in an average semester?
5. In the context of the science classroom and in the order of your goals and objectives, what do you think is important to teach in science classes?
6. What are the science teachers' priorities for the eight environmental science problems/threats?

Experimental Design

A questionnaire (see Appendix) was designed in two parts. The first part was comprised of the above first five open ended questions. The answers to the questions were used to determine what ideas the teachers held regarding their teaching and the environmental and technological problems. Question four of part one required teachers to check a range. Question five of part one had five sub questions that required teachers to rank themselves on a scale from 1-10 regarding the importance they gave to each sub question. In order to devise the current questionnaire, a previous study was conducted with small samples of Spanish teachers. This confirmed that, in general, teachers had no problems in understanding the meaning of questions.

The content validity of the questionnaire and its relevance to the goals was justified by the competency and professional expertise of the researchers and qualified and experienced members of faculty in science and science education. The members of the faculty of science and science education filled out the questionnaire and made suggestions that were taken into account in writing the last version of the questionnaire.

Next, a description of the process followed to analyze the answers is given. A set of categories was devised for each question on the basis of the goals established in an initial session. Then a member of the research team in each country carried out the analysis of the answers to the questionnaire. The students' answers were classified in agreement with the categories defined. The obtained categories were discussed with other members of the research team. The members of the research team in each country then went on to analyze all questionnaires independently.

Part two required the science teachers to rank the eight global environmental science problems/threats according to the importance they gave to them and the priority they felt they should have in public policy. A space was provided on the left margin for ranking them and teachers were instructed to rank them from 1 (most important) to 8 (least important). When ranking the threats, teachers were asked to rank the top three first (1- 3) and the three least important threats (6 -8). Last, they were asked to rank the two middle threats with numbers (4-5). The results of the ranking were analyzed by determining the average rank of each threat. Two-tailed t-test were used to determine the significance (.05 level) of the ranking whenever two subgroups were compared (i.e. male and female and Spanish and US teachers).

Results

Question One: What problems/threats that relate to global technology and the environment do you teach your students about in your science classes?

With respect to question one, teachers put forward a large variety of scientific,technological and environmental problems related to our planet which were grouped in the following way (see Table 3): A-contamination of the Planet, B-Sustainable development and the limited resources of the planet, C-treatment of waste, new materials, alternative energies and good management of the resources, D-genetic engineering, genetically modified food, and loss of biodiversity, E-health and hygiene habits, F- uneven distribution of resources, G-weapons of mass destruction including biological weapons, bio-terrorism and nuclear weapons and H-nuclear waste storage.

Since there were more than twice as many Spanish teachers (89 vs. 42), comparison were made based on the percent of teachers in each group who emphasized the various environmental problems/threats. By doubling the US responses, the two groups are more easily compared. Regarding *contamination of the planet*, a higher percent of US teachers emphasized the severity of this problem, especially in land, air and water contamination. The Spanish teachers cited *acid rain* and *desertification and climate change* as more serious than the US teachers did. The percent of US teachers who mentioned problems relating to *sustainability* was more than double that of the Spanish

Table 3. Spanish and United States teacher responses to question one.

Type of Response	Spanish teachers N = 89	US teachers N = 42
A. Contamination of the Planet:	57 (64.0%)	36 (85.7%)
A.1. Contamination of the land, water and air.	21 (23.6%)	34 (81%)
A.2. Global warming, the ozone layer, CO_2 emissions and the greenhouse effect.	45 (50.6%)	27 (64.2%)
A.3. Acid rain.	21 (23.6%)	7 (16.6%)
A.4. Desertification and climatic change.	20 (22.5%)	2 (4.8%)
B. Sustainable development and the limited resources of the planet	22 (24.7%)	25 (59.5%)
Overpopulation		16 (38%)
C. Treatment of waste, new materials, alternative energies and good management of the resources.	41 (46.0%)	17 (40.5%)
D. Genetic engineering, genetically modified food, and loss of biodiversity.	20 (22.5%)	12 (28.6%)
E. Health and hygiene habits	9 (10.1%)	5 (12.0%)
F. Uneven distribution of resources	3 (3.4%)	0
G. Weapons of mass destruction including biological weapons, bio-terrorism and nuclear weapons	0	4 (9.5%)
H. Nuclear waste storage	0	8 (19.0%)

teachers. Regarding the importance given to *treatment of waste, new materials, alternative energies and good management of the resources*, the Spanish and US groups were quite similar. Likewise, for *genetic engineering, genetically modified food, and loss of biodiversity, endangered species and habitat destruction* and *health and hygiene habits,* both groups were similar in percents. Three Spanish teachers mentioned *uneven distribution of res*ources but no US teachers mentioned this threat. In the last comparison, no Spanish teachers mentioned *weapons of mass destruction* but four US teachers mentioned this threat. Also, eight US teachers mentioned the problems of *nuclear waste storage*

Table 4. Spanish and United States teacher responses to question two

Type of Response	Spanish teachers N = 89	US teachers N = 42
A. Problems related to contamination of the Planet:	42	16
A.1. Ozone layer	5	0
A.2., Emissions of gases	14	2
A.3. Global warming	14	7
B. Measures undertaken towards the sustainable development of the planet and the limited resources of the same were discussed.	43	24
C. Unjust distribution of the natural resources and possible ways to equitably distribute them.	20	0
D. Climatic change and biodiversity.	12	0
E. Biodiversity, clean water and sanitation, economic security, US refusal to back some of the priorities and human rights	-	11

whereas no Spanish teachers mentioned this threat.

Question Two: What were some of the technological problems that were discussed in the 2002 Johannesburg Earth Summit?

When Spanish teachers were questioned about what was dealt with in the Earth summit held in Johannesburg in 2002, almost 30% (25 teachers) recognized that they did not possess enough information to answer the question. 57% (24) of the US teachers did not have any information about the Johannesburg meeting in 2002. Among the Spanish teachers who answered (64 teachers), the majority pointed out problems in very general terms which were not dealt with specifically in that meeting. Nine of the US teachers appeared to know what they were talking about and gave fairly detailed answers. But nine also gave very sketchy or limited information that could not clearly be tied to the Summit.

Among the teachers who replied, the responses were grouped in the following way (see Tables 4):

Question three: Can you describe any reasons why you do or do not teach about environmental and technological problems and or threats in your science classes?

The results of question three regarding why the teachers do or not teach about

environmental and technological problems were classified within the three views of utilitarian, democratic or technological (see Table 5 for the results).

Individual teacher reasons for teaching about environmental problems/threats/.

A. 43 responses from Spanish teachers were arguments that the problems of the planet belong to everyone and education about them is necessary, being a question of survival for the coming generations. 18 responses from US teachers gave support to the ideas that the issues affect our lives and future, they are interrelated and the issues are important to the health of the planet. The above argument is named here, the "conservationist view".

B. 40 Spanish Teacher responses presented the argument that it is necessary to teach the values of democracy and solidarity which lead to responsible attitudes in the treatment of the problems of the planet. Nine responses from US teachers said the problems must be understood by future leaders, students must be informed to be good citizens, including voting, and that all of us are part of a global community and citizens of the earth and the issues are important to all of us. Some teacher responses argued that the science standards mandate environmental science for all students. The above argument is named here, the "democratic vision".

C. Nine Spanish teacher responses explained that it is necessary to inform students about the huge contributions that science has made towards advancements in technology which have influenced our way of life and will be influential in the future. One US teacher stressed using technology wisely and how relevant a knowledge of science is to understanding the problems. This argument has here been named the "Technological view or decontextualized view of science and technology". This view does not take into account, on the one hand, the possible negative consequences of the scientific applications. On the other hand, if science and technology are influential in our way of life, it is also necessary to consider that society exercises a clear influence over the development of scientific investigation, favouring one type of investigation over others.

Among the Spanish teachers, 40% of the teachers interviewed (37 teachers) indicated that they do not teach this type of science and that they only mention the problems in a superficial way. 40% of the US teachers (17) either gave no answer to the question or said they do not use it because of various reasons. The reasons for both Spanish and US teachers are listed below.

A. Some of the Spanish teachers said

Table 5. Spanish and United States teacher views

Categories of replies	Spanish teachers N = 89	US teachers N = 42
Reasons for teaching these subjects	52	25
Conservationist view	43	18
Democratic view	40	9
Technological view	9	1
Reasons for not teaching these subjects	37	17
Lack of training	8	0
Reductionist view	29	13
No answers given	-	8

Table 6. Time dedicated by the Spanish and United Stated teachers

Time dedicated	Spanish teachers (N = 89)	US teachers (N = 42)
None	2 (2.2%)	1 (2.3%)
Once or twice during the course	9 (10.0%)	4 (9.5%)
Once a month	45 (50.5%)	10 (23.8%)
Once a week	20 (22.5%)	17 (40.5%)
Daily	13 (14.6%)	10 (23.8%)

they had not had sufficient training to be able to explain these matters (8 teachers). These teachers seemed conscious of the necessity for training in matters related to technological and environmental problems of the world at this moment, and therefore the importance of including such content. None of he US teachers cited a lack of training for not teaching the issues.

B. 10 Spanish teachers said that there is no time to explain such subjects given that the syllabus is very wide. 13 of the US science teacher responded that they did not have time, the curriculum was too broad or the science standards did not include these issues. One teacher said it was boring. This argument has been named "Reductionist or socially neutral view of Science". It has already been mentioned that this view leaves out the complex relationships between Science, Technology and Society and it will consider science and scientists distant from the decision making process. An extremity of this view is when teachers fail to even consider the subject of STS relationships arguing that they should not enter in the programs for the subject (19 Spanish teachers). Eight US teachers did not answer this question.

Question Four: How much coverage do you give to technological and environmental problems/threats in your science classes in an average semester? See Tables 6 for the results.

33 Spanish teachers (37.1%) dedicated time to the treatment of these problems and reflected with the students about the positive and negative aspects of scientific development, and in this way searched for solutions together. In contrast, 64.3% of the US teachers dealt with the issues and problems daily or once a week when teaching science.

At the same time, 45 of the Spanish teachers questioned (50.5%) indicated that they discussed the aforementioned problems once a month (about 8 times during the course) but recognized that the time dedicated was very small and that the subjects were only mentioned briefly without going into depth (23 teachers out of the 45). 10 US teachers (23.8%) dedicated time once a month to discussing these problems. Finally, 12.2% of the Spanish and 11.8 % of the US teachers dedicated very little time or no time at all to dealing with these problems when teaching science.

Question Five: In the context of the science classroom and in the order of your goals and objectives, what do you think is important to teach in science classes?

In question 5, proposals were made and formulated in a positive way to find out the opinions of the teachers with regard to the goals and objectives of the teaching of science in secondary education. In each proposition, one of the possible objectives for teaching science indicated by science education investigation was prioritized. In this way, proposition 5a underlines the

Table 7. Spanish and United States teacher evaluations of the five propositions

Evaluations (from 0 to 10) of the science teachers	Spanish Teachers N = 89 Mean (SD)	US Teachers N = 42 Mean (SD)
5a. To discover how scientists work to evaluate scientific-technological problems.	7.37 (2.31)	7.17 (2.24)
5b. To learn the concepts and theories, to reach a level of understanding that allows them to continue their studies successfully.	8.08 (1.90)	7.35 (2.16)
5c. To acquire the democratic values of the current social environment.	7.35 (2.65)	7.75 (2.37)
5d. To acquire scientific literacy in order to become informed citizens in present day society.	8.55 (1.64)	8.75 (1.93)

procedural aspects of scientific research, 5b underlines the need to know concepts and laws for future studies, 5c prioritizes the attitudinal aspects of the curriculum and 5d underlines the necessity of teaching science to produce citizens capable of making decisions in contemporary society.

The teachers were asked to evaluate the different propositions (a-d) from 0 to 10. Even though an attempt was made to prioritize the objectives of science teachers, it is clear that the teachers questioned gave importance to all the propositions (see Table 7).

Among the Spanish and US science teachers, the most highly valued goal was 5d, science literacy followed by 5b learning science concepts and theories for the Spanish teachers and democratic values, 5c, for the US teachers. The least valued goal of the Spanish science teachers was proposition 5c, acquiring democratic values while for the US teachers,' it was learning how scientists work to evaluate scientific-technological problems, 5a.

The attitude of the teaching profession towards the term "scientific literacy" is positive (proposition 5d). If this was the criteria for evaluating whether teachers teach questions related to scientific literacy, the response would be very positive. However, according to the previous questions, it seems that the term encompasses a slogan which is widely used and rarely defined in practise (Furió et al. 2002). To sum up, it is observed that, at least on paper, teachers consider all the goals and objectives put forward to be of importance.

Research Question Six: What are the science teachers' priorities for the eight environmental science problems/threats?

This research question was answered by means and rankings of the problems/threats for all teachers, by nationality and gender (see table 8). Of the original 42

Table 8. Means and Rankings of the eight problems/threats by nationality and gender.

Problem/Threat	Spanish Teachers N=89	Males 39	Females 50	US Teachers N=40	Males 17	Females 23
Conflicts and Violence	3.78 (3)	3.77 (3 or 4)	3.80 (3)	5.69 (6 or 7)	4.82 (6)	6.60 (7)
Depletion of Natural Resources	3.70 (2)	3.77 (3 or 4)	3.64 (1)	2.59 (1)	2.82 (1)	2.43 (1)
Ecosystem Degradation	4.68 (5)	4.31 (5)	5.06 (6)	3.09 (2)	3.11 (2)	3.08 (2)
Environmental Pollution	5.03 (6)	5.03 (6)	5.04 (5)	3.24 (3)	3.41 (3)	3.13 (3)
Human Health And Disease	5.11 (7)	5.05 (7)	5.18 (7)	4.94 (5)	4.52 (5)	5.26 (6)
Land Use	6.36 (8)	6.46 (8)	6.26 (8)	4.09 (4)	4.23 (4)	4.00 (4)
Sustainable Development	3.95 (4)	3.41 (2)	4.50 (4)	5.69 (6 or 7)	6.47 (7 or 8)	5.13 (5)
World Hunger and (7 or 8)	3.52 (1)	3.26 (1)	3.78 (2)	6.57 (8)	6.47	6.65 (8)

Table 9. Comparison of male and female groups

Threat	All N= 89	Male N= 39	Male SD	Female N= 50	Female SD	T value	Level
Conflicts and violence	3.78	3.77	2.54	3.80	2.70	0.05	-
Depletion of natural resources	3.70	3.77	1.77	3.64	2.15	-0.31	-
Ecosystem degradation	4.68	4.31	2.02	5.06	1.68	1.91	0.06
Environmental pollution	5.03	5.03	1.87	5.04	1.84	0.03	-
Human health and disease	5.11	5.05	2.18	5.18	2.40	0.26	-
Land use	6.36	6.46	2.01	6.26	2.14	-0.45	-
Sustainable development	3.95	3.41	2.39	4.50	2.95	1.88	0.07
World hunger and food	3.52						

US teachers, one male and one female did not answer question six.

The top three technological and environmental threats mentioned by all Spanish teachers in descending order were World Hunger and Food Resources, Depletion of Natural Resources and Conflicts and Violence. The top three for the US teachers were Depletion of Natural Resources, Ecosystem Degradation and Environmental Pollution. Human Health and Disease (7) and Land Use (8) were the least importance to the Spanish teachers. World Hunger and Food Resources (8) and Sustainable Development (6 or 7) and Conflicts and Violence (6 or 7) were the least important to the US teachers.

When gender was considered, the Spanish males ranked World Hunger and Food Resources as the most important, Sustainable Development as second and Conflicts and Violence or Depletion of Natural Resources as third and fourth. The female groups had the same top four choices but in a different order. In both groups the problems/threats least valued were Land Use and Human Health and Disease. When gender was considered, the US males and females ranked the top three threats the same. The least important threats were World Hunger and Food Resources for males and females (8) but Conflicts and Violence was number 7 for females and either 6 or 7 for males. In general, for the top three threats and the least important threats, the gender differences in the US group were less pronounced than in the Spanish group.

Since gender differences were more pronounced for the Spanish group, two tailed t-tests were calculated for significance at the .05 level (see table 9).

Regarding the comparison between male and female Spanish science teachers, the data indicated no significant differences at the .05 level. Both ecosystem degradation

(.06) and sustainable development (.07) were close.

Discussion

Regarding question one, the problems/threats that relate to global technology and the environment taught by the two groups of teachers, the following explanations are offered: The American teachers seem to have a greater sensitivity towards problems related to contamination of the planet (85.7%), global warming (64.2%) and sustainable development (59.5%). In part, this may be due to the current political situation in the US. Under the current federal administration since the year 2000, environmental protection has taken a back burner to the priorities of business and both the department of Interior and the Environmental Protection Agency have relaxed or refused to enforce many laws and regulations that formerly protected the air, water and land in the US. The President has also issued many new regulations without the consent of Congress that either remove or undermine the ability to enforce many environmental regulations. Furthermore, the Bush administration has shown no support for policies that would reduce fossil fuel use with the prospect for stabilizing and reducing greenhouse gases that contribute to global warming. California and some other states have taken the lead in setting up their own regulations and other western states may be influenced by this. Nevada in particular is a state that has great potential for alternative energy in geothermal, solar and wind.

At the same time, half the Spanish teachers showed a high concern for global warming. This concern could be due to the problems of water supply and desertification which the south of Spain is beginning to suffer from and which are at present the subject of debate in politics and the media.

The big difference in emphasis given by the US teachers to weapons of mass destruction and nuclear waste storage may be related to the fact that the teachers are from Nevada, and that state has been designated as the nuclear waste storage site for the US with the result that a lot of citizen awareness has been promoted by the media regarding this perceived threat to Nevada business interests. It was surprising that sustainability was ranked so high given the high level of consumption in the US and the current administration at the federal level giving little emphasis to conservation or energy efficiency. Carrying capacity and sustainability are important topics in the environmental science curriculum, and most of the science teachers who participated in the study were trained in general science and environmental science methods classes that emphasized sustainability and carrying capacity through resources such as *State of the World* (Worldwatch Institute, 2006). This may have impacted their ranking.

Regarding question two, and judging by the Spanish and US teacher responses, one might conclude that a large majority of teachers have no current knowledge about the agenda of the World Summit on sustainable development which dealt with specific scientific and technical development related to the environment and the evolution of the planet. In general, the Spanish teachers did seem better informed than the US teachers. A possible explanation for this is the way the US government played down the summit (Dunn, 2002) and even tried to undermine some of the agenda for fear it would make the US look bad. The part that dealt with global climate change was especially significant, perhaps because President Bush has had such a dismal record on environmental issues in general and the fact that he broke his pre election campaign promise to sign the Kyoto Agreement after being elected. His administration has continued to undermine what scientists say about global climate change and other science based environmental issues (www.ucsusa.org,2006). In contrast, in Spain, the programme of the new socialist government includes observance to the protocol of Kyoto and has already begun to take steps towards compliance, with the approval of the majority of the population. With respect to the problem of sustainable development, although it has not been considered as a priority theme to be debated in class (only 25% mention it in reply to question 1), they do seem to be aware of the problem (almost half the replies to question 2).

Regarding Question three, reasons why the teachers do teach about technological and environmental problems and or threats in their science classes, the evidence indicates that both groups of teachers had similar thoughts about the need to conserve the planet for everyone, including future generations. Apparently nearly one-half of the science teachers in both countries see the teaching of science and its related environmental problems/threats as a utilitarian need. This has historical origins in the US during the 19th century when biology and health were both put in the school curriculum because of social relevance (DeBoer, 1991).

Nearly one-half of the Spanish teachers had responses within the democratic view for teaching science. A possible reason for this could be the Spanish educational reform proposed in the 90s which extended compulsory education to the age of 16 years. One of the principal goals of this extension was the democratic right of people to cultural, scientific and technological literacy. Among others priorities, the Spanish secondary scientific education reform (12-16 years old) stated the need for scientific and technological literacy of pupils.

The percentage of responses of US teachers that fell within the democratic view is less than half of that of the Spanish teachers. The recent science standards in Nevada, as well as many other states, do not emphasize the need for students to know science to be informed voters regarding issues that require science literacy. The national science standards (NRC, 1996) are underpinned by science literacy as one of two main goals for teaching science, the other being inquiry. They do emphasize science and social issue and science and technology but some state standards were weak in incorporating these ideas and they are not as likely to be stressed by science teachers. Personal experience of the American author indicates the reluctance of Nevada science teachers to incorporate science, technology and society (STS) methods into their science classes. In fact, there are many complaints that citizenship skills in general are not stressed enough in US education with the time for them being preempted by time given to the standards and the academic knowledge emphasized by the No Child Left Behind Mandate (2002).

A much higher percent of Spanish science teachers stressed the importance of informing students about the contributions of science to technological advances although it was still small in the total group. One explanation for this is that US science teachers and the public as well seem to take technology for granted and have little appreciation for science and engineering as essentials for a modern, technology based society (Robinson and Maddox, 1999).

Regarding the reasons why science teachers do not teach about technological and environmental problems and or threats in their science classes, more Spanish teachers mentioned lack of training. This is puzzling since 26 of the US teachers were teaching grades 7-8 and nine did not have degrees in science areas. Only four of the US teachers were under 30 and it is assumed that most of them have many years of teaching in their subject area. If this is true, they presumably would have learned the science they thought they needed to teach their subject through the many years of experience. In the case of the Spanish teachers, their responses of lack of training are coherent with their curriculum because 60% of teachers are more than 35 years old and twenty or more years ago the degree and masters in physics, chemistry or biology did not deal with subjects related to general problems of the planet.

Percentage wise, many more US teachers indicated that they did not have time to bring in environmental and technological problems/threats. A number of them mentioned directly that the standards made it difficult to have the time to connect science to societal issues. Teachers will be held accountable for how their students do on the science exit exams and more and more of them are teaching to the test and leaving out essential connections to society that would enable students to see the value of learning science as a means to understanding science and technology based societal issues.

Question Four dealt with coverage given to technological and environmental problems/threats in science classes in an average semester? A higher percentage of US (64.3%) than Spanish (37.1%) teachers said they covered technological and environmental problems/threats on a daily or weekly basis. Still, the percentages were low for both groups. Given the fact that most US teachers now have to teach to the science standards and most of them do not directly include technology and the environment, it is surprising that more than one-half of the teachers bring the issues in regularly. An attempt is being made in teacher training classes to try to get science teachers to use more science and technology based current events in their lessons. The hope is that this will help teachers connect science to everyday issues thereby helping students to see science as relevant and perhaps more interesting as well. The low percentage of Spanish teachers who show a high level of interest in relating their teaching to these subjects is consistent with the reductionist view of the science programme and the "lack of time" explained in question 3. Moreover, Spanish science standards do not include these issues directly.

Question five dealt with the most important goal science teachers have when they teach science. The most important goal of both groups of teachers was helping students become science literate to become informed citizens. This is one of the two main goals of science education in the US and in Spain. The content and process skills in the national and state science standards are aimed at helping student become science literate. The results from this question seem to contradict the results of educational practice that the teachers say they practice. In question three, 40 of the Spanish teachers questioned do not teach subjects related to scientific literacy such as the scientific-technological and environmental problems of the earth and over half of those who made reference to these matters recognized that it was done in a superficial and hurried manner (question four). Likewise, 17 of the US teachers did not answer the question at all or gave reasons for why they cannot emphasize content areas

that involve science literacy. The results of questions three, four and five, analyzed together, seem to indicate that a significant difference exists between the good intentions of both the Spanish and US teachers (question 5) and the reality of practice in the classroom (questions three and four). Part of the problem with the US and Spanish teachers' seems to be that many of them think they are addressing science literacy if they teach the standards. The US author and many of his colleagues believe that the standards do not make the necessary overt connections to societal issues to help students become science literate. The students may be able to recall science concepts but they are not able to make applications and connections of this information to society in a true STS fashion (Yager and McCormick, 1989).

The second main goal of science teaching for the Spanish teachers was the learning of concepts and theories to continue successful studies. This result is coherent with the Spanish secondary science education standards before the educational reform in the 90s. Before the reform, the function of science instruction in secondary education was exclusively preparation for university studies (Gil, Furió and Gavidia, 1998). The second main goal for the US teachers was the acquisition of democratic values. This would fit with the goal of science literacy but it to some degree contradicts question three. In answering that question, less than one-quarter of the US teachers gave reasons for teaching about environmental problems and threats that were within the democratic view.

In regard to Question six, the results of the ranking of the eight issues by the Spanish teachers appear to indicate a social preoccupation of the teachers convergent with a "conservationist" and "solidarity" view "with respect to the problems of the planet which also comprise the majority of the arguments used by the teachers in question three. The problems which are continually mentioned in society (Hunger and Food Resources and Conflicts and Violence) appear to be influential in the priorities marked by the teachers. The priority given to the problem of Depletion of Natural Resources is convergent with the results of the first question where almost half of the teachers (see table 4, C.) mention problems related to recycling of waste and alternative energies. The priority given to the problem of "sustainable development" is also convergent with the results of section B of the first question (see table 1). However, the problem of "environmental pollution" is not convergent with the results of the first question, given that it is the least mentioned and does not seem to be the one of the most highly prioritised in the classification.

The results of the rankings of the US teachers indicate that loss of and degradation of resources are a real priority. Water is a very big problem in this part of the US and there is real fear that continued development will decrease the quality of life both through resource depletion and degraded resources. Land use is also seen as a priority. Continued development around Lake Tahoe and in some of the most scenic areas of the Sierra Nevada mountains are issues that are regularly in the news. Many more bears, coyotes and cougars are now seen and captured and relocated or killed, from newly developed areas as humans continue to take over what was formerly habitat of wild animals. Food resources were not seen as a problem and given the news about obesity in both adults and school age children, it is suspected that there is no transfer to what is going on in much of the underdeveloped world. Most foreign news deals with Iraq and issues such as starvation in the Darfur region of Sudan rarely make the news.

It seems apparent that for these teachers in the developed world, the problems related to 'human health and disease' and 'land use' are not priorities. This lack of concern is convergent with the results of the first question. The place which they occupy in the list of priorities seems in some way logical given that the basic sanitary problems in Spain are reasonably covered and health service is available for the whole population including immigrants, unemployed and the homeless However, causes for concern such as AIDS, adolescent pregnancy, etc. still exist. The division of land happened a long time ago and does not seem to be a cause of concern, although matters such as property speculation, desertification, irrational use of water etc, should all be motives for greater concern.

Conclusions and Implications for Teaching

The authors think that the questions posed have led to an increase in our knowledge about the opinions of the science teaching faculty concerning the teaching of global science and technology based problems/threats. The results indicated that the teachers of both countries are worried about the problem of pollution of the planet. The US teachers showed greater sensitivity to the problems related to sustainable development and the limited resources of the planet, while the Spanish were more concerned about problems regarding the unjust distribution of the natural resources and possible ways to equitably distribute them.

In the second part of the questionnaire it can be observed that the US and Spanish teachers emphasized different problems in accordance with the social and geographical environment in which they live. In other words, local experiences may have the biggest impact on priorities. This supports earlier research by one author (Robinson et al., 1997) regarding the ranking of environmental issues and problems in Poland by Polish high school students and teachers. The problems that Spain has derived from the massive immigration from Africa caused by the problems of hunger and violence are reflected in two of the three principle concerns of the teachers. Likewise, the American teachers from the western US reflected the concern for the deterioration of the land within their first four problems. Nevertheless both groups of teachers indicated the problem of the depletion of natural resources among their three priorities.

The majority of both teacher groups recognized that they do not dedicate much time to the treatment of these subjects in class. They indicated that there is not enough time or that they do not consider them to be within the standards. This is in contradiction to the objective of increasing science literacy in their students

expressed by both groups. One possible explanation for this contradiction is that the majority of US and Spanish teachers think that they achieve the aim of literacy by teaching to the curriculum standards. US secondary science teachers will soon be held accountable for how well their students do on the external exams that address the science standards. Furthermore, in the case of the Spanish teachers, this attitude may be due to the fact that until the 90's the main objective of secondary teaching was the preparation of students for university studies and therefore the prevalence was for content focussed on the theories and laws of the discipline.

In accordance with the results obtained in this study, it seems prudent to propose some ideas regarding actions or activities that teachers should include in their secondary teaching to give more value to global science and technology based problems/threats as important parts of scientific literacy for future citizens, including future scientists. To achieve this change of perception among the teaching staff, with regard to the purposes of the curriculum, is a complex issue that will require institutional and social support. It will be necessary to develop programs, for example, courses, workshops or other teacher training activities aimed at reflecting collectively on which curricular changes can contribute to improving education and, more precisely, to raise the question about why in Spain, the sciences are taught in the compulsory curriculum (Guisasola et al. 2001). In the US, the NCLB law will soon be revised and science standards in many states are also under revision. Furthermore, society has to understand that it is important for its immediate development to obtain quality scientific education for all citizens. The opinion of the US author is that the science literacy needs of most students, those not pursuing careers in science related fields, and the country as a whole, would be far better served by much more emphasis being given in the standards to environmental science instead of the traditional science courses. The role of the teachers' activity in education has to be reconsidered in this context. In Spain, this reconsideration demands the acceptance on the part of the Ministry of Education that the purpose of education should consist not only in teachers preparing and correctly carrying out their role in the classroom, but should also include their involvement in activities of educational innovation and research. This is the only way that it will be possible to enable the teaching staff to reflect on and accept the new directions as their own and to participate in the curricular changes, which in this case, include both its purposes and objectives.

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Appendix

Part I

As citizens of the world, we face many public policy problems related to the technological and environmental changes that affect humanity and the rest of life on Earth. We invite you to reflect on the relationship between the science that you teach and the problems and challenges that, in your opinion, humanity faces now and will face in the near future.

Please answer the following:

1. What problems / threats that relate to global technology and the environment do you teach your students about in your science classes?
2. What were some of technological and environmental problems and or threats that were discussed in the 2002 Johannesburg Earth Summit?
3. Can you describe any reasons why you do or do not teach about technological and environmental problems and or threats in your science classes?

Please circle the number you most agree with for the following questions:

4. How much coverage do you give to technological and environmental problems / threats in your science classes in an average semester? Circle the number that best applies.

1, 2, 3, 4, 5
None Once or twice Once a month Once a week Daily

5. In the context of the science classroom and in the order of your goals and objectives, what do you think is important to teach in science classes?

** Value from 10 (full agreement) to 0 (full disagreement)

a. Science classes must teach students how scientists work so students can assess better the everyday technological and environmental problems / threats they face _____ 1-10
b. Science classes must teach scientific concepts and theories thoroughly enough to enable students to pursue further studies of everyday technological and environmental problems and or threats. _____ 1-10
c. Science classes must teach information that enables student to acquire the democratic values needed in the social environment in which they live._____ 1-10
d. Science classes must teach students the essential scientific and technological literacy needed by informed citizens in contemporary society. _____ 1-10

Part II

Global Environmental Problems / Threats

There are many public policy problems confronting citizens throughout the earth. The priority that governments and citizens give to the problems can vary in different countries. We would like you to rank the following global environmental problems / threats according to how important you think they are and the priority they should have in public policy.

Many of the nine (A-I) problems / threats are related to one another. This makes selection of one problem over another somewhat difficult. With this understanding, we ask that you do your best to rank the most significant problem and or threat with a number 1, the second with number 2 and so on to number 8. It might be easiest rank the top three first (1-3), the bottom three second (6-8) and the middle two last (4-5).

A_____Conflicts and Violence (regional inequalities in the world, cultural and religious differences, increased access to war technologies including chemical, biological and nuclear agents, terrorism, Mafia activities, trans national enterprises which escape democratic control, etc.)

B_____Depletion of Natural Resources (Water, Minerals and Land; water and energy conservation, efficiency and reuse, alternative energy, loss of watersheds, water distribution, deforestation, desertification, reclamation, soil erosion, urban development etc.)

C_____Ecosystem Degradation (loss of biological diversity, extinction of plants and animals, wildlife habitat loss, ecological services, affects on human health, etc.)

D_____Environmental Pollution and its Consequences (Air and Atmosphere Quality, vehicle and power plant emissions, acid rain, global climatic change; Water Pollution, ground water contamination, human and industrial waste disposal, Land Toxicity, waste dumps, toxic chemicals, effects on human health, etc.)

E_____Human Health and Disease (infectious and non-infectious disease, antibiotic resistance, stress, diet and nutrition, exercise, mental health, pollution, etc.)

F_____ Land Use (The demographic explosion, a finite planet, population growth, resource degradation and depletion, carrying capacity, etc.)

G_____Sustainable Development (world economics and politics, loss of ecosystems and environmental degradation, corporate expansion, World Trade Organization, etc.)

H____World Hunger and Food Resources (processed food, genetically engineered foods, corporate agriculture, cropland conservation, etc.)

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