The Current Planetary Crisis: a Missing Dimension in Science Education[*]

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Abstract

The origin of our research has been the intuition that, in spite of some dramatic calls of United Nations experts, the attention paid by science education research to the study of citizens' awareness of the state of the world and of the danger of an irreversible degradation of life in our Planet, has been very poor. Our work intends to clarify to what extent this essential issue in the education of future decision-making citizens is adequately dealt with in science education research. With this purpose, we have posed open questions to several hundreds of science teachers in training and in service about "*problems and challenges that humanity has to face*" and we have analysed the content of high school science textbooks (looking for any reference to the state of the world and its future). Results obtained explain why we refer to the state of the world as a missing dimension in science education. This dimension should be urgently incorporated if we want to answer the United Nations call to contribute to the Decade of Education for a Sustainable Future.

Key Words: Science Education, Sustainability, Teacher Education

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Introduction

During the United Nations Conferences on the Environment and Development, held in Rio in 1992 and Johannesburg in 2002, educators *of all subjects and levels* were asked to contribute to the public's awareness and understanding of the problems and challenges related to our planet's future in order to make it possible for citizens to participate in well-founded decision-making. Moreover, after the Johannesburg Conference, The United Nations General Assembly unanimously approved a resolution that established a Decade of Education for Sustainable Development (2005-2014), and proclaimed UNESCO the agency in charge of its promotion.

But why should *all educators* incorporate *the state of the planet* as an important part of their teaching? And why *now*?

We must remember that until the second half of the 20th Century our planet seemed to individuals to be very large, practically limitless, and the effects of human activities remained locally compartmentalized. But these compartments have begun to dissolve over the last few decades and many problems (the greenhouse effect, ozone depletion, acid rain…) have acquired a global dimension (Bybee, 1991; Fien, 1995; Colborn, Myers and Dumanoski, 1997; Gil-Pérez et al., 2003; Vilches & Gil-Pérez, 2003). This particularly applies to the various global *crises* that have sparked public concern, especially in the last decade. These are not separate crises: an environmental crisis, a development crisis and, more particularly over the last decade, an energy crisis. They are all one (World Commission on Environment and Development, 1987; Giddens, 1999). In short, we can speak of a *planetary crisis* (Bybee, 1991; Orr, 1995), and the state of our planet has thus become the subject of growing concern.

But, what is the situation today, more than twelve years after the Rio Conference, in the first year of the Decade of Education for a Sustainable Future? Our hypothesis is that, in spite of such dramatic appeals, the attention paid by curriculum planners, science teachers and science education researchers to the state of our planet is still very poor and constitutes a serious *missing dimension* in science education research and innovation (Gil-Pérez, 2001; Vilches et al., 2003). In order to put this hypothesis to the test, we analysed science teachers' perceptions, the content of high school science textbooks and papers published in science education journals. In the first instance, however, this analysis requires that the current planetary crisis be clarified.

The need for a holistic view

If we wish to correctly understand the current planetary emergency and how we should act, we must go beyond considering concrete or local environmental problems and contemplate the holistic nature of environmental education (Gayford, 1998). We need to construct a global picture of the state of Planet Earth and to study the possible causes and remedies thoroughly. To achieve this:

- We have taken into account the contributions of different studies undertaken from an explicitly global point of view, such as the Worldwatch annual dossiers on '*the state of the world*' (Worldwatch Institute, 1984-2005), 'Our Common Future' (World Commission on Environment and Development, 1987), 'The First Global Revolution' (King and Schneider, 1991) 'Agenda 21' (United Nations, 1992), The United Nations Development Programme Reports 1990-2005, 'The World Ahead: Our Future in the Making' (Mayor Zaragoza, 2000); '*Something New Under the Sun. An Environmental History of the Twentieth-Century World*' (McNeill, 2003) or '*High Tide. News from a Warming World*' (Lynas, 2004).

- We have also analysed papers published on this subject in science education and environmental education journals.

- Finally, we have undertaken a Delphi study (Gil-Pérez, 2001) involving several dozen science teachers of all levels and from different countries.

These studies have enabled us to construct a network (**Table 1**) summarising the collection of *related* problems, causes and challenges which characterise the state of the world (Gil-Pérez, 2001).

Before commenting on the different items and discussing the attention paid to them by science teachers, science textbooks and science education research, we shall briefly explain how these results were obtained .

Table 1. Problems and challenges which characterise the present state and near future of the world

0) The main aim should be to lay the foundations of sustainable development

This draws our attention to a collection of interconnected aims and actions:

1) To put an end to socioeconomic growth guided by private interests in the short term, which seriously damage the environment and are particularly dangerous to living beings

This economic growth produces, among other things, the following problems:

1.1. Increasingly disordered and speculative urbanisation

1.2. Environmental pollution and its consequences (greenhouse effect, acid rain…)

1.3. Depletion of natural resources (fossil energy resources, fertile soil, drinking water…)

1.4. Ecosystem degradation and destruction of biological diversity

1.5. Destruction, particularly where cultural diversity is concerned

2) To put an end to the following causes (and their consequences) of unsustainable socioeconomic growth:

2.1. Over-consumption in "developed" societies and dominant groups

2.2. Demographic explosion on a limited planet

2.3. Social inequalities between human groups

2.4. Conflicts and violence associated with these inequalities (military conflicts, Mafia activities, speculation on the part of transnational companies that escape any democratic control…)

3) To adopt positive measures in the following fields:

3.1. Political measures on a planetary scale capable of promoting and controlling the necessary protection of the social and physical environment before the current degradation processes become irreversible

3.2. Educational measures to overcome the general tendency to behave according to individual short term interests, making it possible to promote solidarity by means of changes in personal values and lifestyle choices

3.3. Technological measures to better satisfy human needs capable of favouring sustainable development without damaging the environment, including, for example, the search for new energy sources, the improvement of efficiency in food production, the prevention of illness and catastrophes or the reduction and recycling of waste

4) To associate the preceding measures with the need to universalise and expand human rights

4.1. Democratic civil rights (opinion, association…) for everybody as a condition sine qua non for citizens' decision-making about current and future environmental and social problems

4.2. Economic, social and cultural rights (to a satisfactory job, to health, to education …)

4.2.* The right, in particular, to investigate any kind of subject (life's origin, genetic manipulation…) without ideological limitations, but with a social control that takes into consideration the social and environmental consequences and prevents the hasty application of insufficiently tested technologies.

4.3. Solidarity rights (the right to a healthy environment, the right to peace and the right to sustainable development)

Experimental design

In order to ascertain the extent to which science education adequately approaches the state of the world, we conceived several research techniques, as follows:

- to give an open question to teachers in training and in service about "*problems and challenges that humanity has to face*" (see **Table 2**), in order to see if they make any reference to the different aspects concerning the state of the world included in Table 1;

This open question was put to large samples of science teachers involved in science education courses in Spain, Portugal and Latin America (Argentina, Brazil, Chile, Cuba, Mexico, Panama etc…). A total of 327 teachers in service and 521 in training were asked this question. We must stress that they were ordinary science teachers involved in ordinary teacher education courses, without any type of bias.

Table 2. Open-ended question aimed at eliciting science teachers' perceptions of the state of the world.

THE PROBLEMS AND CHALLENGES THAT HUMANITY HAS TO FACE NOWADAYS

We live in a time of accelerated changes and growing concern about how these changes are affecting humanity and all life on earth. This concern about the "state of the world" must have

a clear echo in science education and generate studies capable of helping us to make well-founded decisions.

We invite you to participate in one of these studies, by ***enumerating the problems and challenges that, in your opinion, humanity has to face nowadays and in the near future***. capable of favouring sustainable development. With your help, we intend to construct collectively as complete and correct an image as possible of the current situation ***and of the measures to be adopted in the future.***

- to analyse the contents of high school science textbooks (looking for any reference to the state of the world and its future). We analysed 127 Spanish high school science textbooks (Biology, Chemistry, Physics) published since 1992 (after the Rio Conference).

- We used other techniques to elicit teachers' perceptions about the state of the world. For instance, we asked teachers to make comments about a typical answer to the open question, specifically indicating which other aspects should be contemplated. In this way teachers did not feel they were being judged (since they were being asked to criticise) and they had more time to think about new aspects besides those that are most common. However, the results obtained using these different techniques were very similar and were analysed together.

The information collected in these ways was analysed using the network elaborated to summarise the collection of *related* problems, causes and challenges that characterise the state of the world (Table 1). We looked for references to the different items in the network using very open criteria: *the slightest mention was accepted as a positive result.*

We will now comment on the different items and at the same time present the results obtained.

A global view of the problems that affect our survival

When thinking about problems and challenges concerning the future of humanity, the basic aim signalled by experts is to lay as far as possible the foundations of *sustainable development* (World Commission on Environment and Development, 1987; Folch, 1998; Gayford, 1998; United Nations Development Programme, 1999; Giddens, 1999; Schmandt & Ward, 2000), that is to say, of development that "meets the needs of the present without

compromising the ability of future generations to meet their own needs". This classical definition of the World Commission on Environment and Development (1987) has obtained widespread consensus, although sometimes this consensus is purely formal and hides serious misunderstandings, such as interpreting 'sustainable *development'* as 'sustained *growth'*, which is, of course, the opposite. As Daly (1991) points out, we have to distinguish between growth and development. Growth is a quantitative increase on a physical scale while development is the qualitative improvement or the unfolding of potentialities… In view of the fact that the human economy is a subsystem of a global ecosystem which does not grow, although it develops, it is clear that economic growth is not sustainable over a long period. For this reason, the expression 'sustainable development' has begun to be critically analysed (Plant, 1995; Luffiego & Rabadán, 2000), giving rise to the use of other expressions, such as 'sustainable future' or the *'construction of a sustainable society'* (Roodman, 1999). Nevertheless, sustainability continues to be "*the central unifying idea society most needs at this point in human history*" (Bybee, 1991). What are science teachers' views about this? Do high school science textbooks make reference to sustainability? What is the attention paid by science education journals to this grounding concept?

References to sustainability

From the evidence of our surveys, references to sustainability are unfortunately rare among science teachers in training and in service. **Table 3** gives the percentages and standard deviations of the responses of science teachers (in service and in training) that make any reference to sustainability.

Table 3. Science teachers' references to sustainability

Teachers in service (N= 327)		Teachers in training (N =521)	
%	s. d	%	s. d
7.3	(1.4)	4.1	(0.9)

Even among specialists in environmental education outside our survey, approaches are in general of a local or partial nature; references to global considerations, such as the idea of sustainable development, are very rare (Hicks and Holden, 1995). Figures corresponding to science textbooks are a bit higher, but still very low: 15.7 (s.d. 3.2).

But, how are we to move towards a sustainable society? Experts refer to the necessity to put an end to a series of *interconnected* facts, each one having a particular importance and deserving individual attention, but completely linked to the rest. None of them can be understood or treated without taking into account the whole ensemble (World Commission on Environment and Development, 1987; United Nations, 1992; Fien, 1995; Tilbury, 1995; Mayor Zaragoza, 2000). It is not enough, for instance, to criticise - as is usually the case - environmental pollution and its consequences (greenhouse effect, acid rain…) or the depletion of natural resources without taking into account other related problems.

Attention to the problems that affect our survival and their causes

Quite high percentages of science teachers – both in service and in training - signal environmental pollution, depletion of natural resources and destruction of biological diversity among the main problems humanity has to face (see **Table 4**). On the other hand, there are few references to related problems, such as growing and disorderly urbanisation (World Commission on Environment and Development, 1987; Girardet, 2001) or the destruction of *cultural* diversity (Delors, 1996; Giddens, 1999; Mayor Zaragoza, 2000; Vilches & Gil-Pérez, 2003; United Nations Development Programme, 2004). Less than 20 % make any reference to these aspects.

Table 4. Science teachers' attention to the problems that affect the survival of humanity and their causes

Problems and challenges	Teachers in service N= 327		Teachers in training N=521	
	%	(sd)	%	(sd)
1. Socioeconomic growth, guided by individual interests …	40.4	(2.7)	42.8	(2.2)
1.1 Growing, disorderly and speculative urbanisation...	5.8	(1.3)	5.8	(1.0)
1.2 Environmental pollution and its consequences	49.2	(2.8)	60.5	(2.1)
1.3 Depletion of natural resources	37.0	(2.7)	31.5	(2.0)
1.4 Ecosystem degradation. Destruction of biol. diversity	50.2	(2.8)	58.4	(2.2)

1.5 Destruction, in particular, of cultural diversity	17.4	(2.1)	12.3	(1.4)
2.1 Over-consumption in 'developed' societies	7.3	(1.4)	8.6	(1.2)
2.2 Demographic explosion on a limited planet	20.5	(2.2)	17.7	(1.7)
2.3. Social inequalities among human groups	52.9	(2.8)	48.2	(2.2)
2.4. Conflicts and violence associated with these inequalities	28.4	(2.5)	35.7	(2.1)

We find similar results in science education journals and, although percentages are generally higher in high school science textbooks, references to the destruction of cultural diversity do not reach 9% (see **Table 5**).

This very frequent omission is a clear example of the reductionism that characterises science teachers' views - and even environmental educators' views (Fien, 1995) - about our planet's problems. Against these reductionist views, it is necessary to recognise that "environmental and development problems are not solely caused by physical and biological factors" and that "an understanding of the parts played by aesthetic, social, economic, political, historical and cultural elements is required" (Tilbury, 1995).

Table 5. Attention to the problems that affect the survival of humanity and their causes in high school science textbooks

Problems and challenges	Science textbooks N = 138	
	%	(sd)
1. Socioeconomic growth, guided by individual interests …	58.3	(4.5)
1.1 Growing, disorderly and speculative urbanisation...	36.2	(4.3)
1.2 Environmental pollution and its consequences	88.2	(2.9)
1.3 Depletion of natural resources	57.5	(4.4)
1.4 Ecosystem degradation. Destruction of biol. diversity	83.5	(3.3)
1.5 Destruction, in particular, of cultural diversity	8.7	(2.5)

2.1 Over-consumption in 'developed' societies	29.9	(4.1)
2.2 Demographic explosion on a limited planet	33.1	(4.2)
2.3. Social inequalities among human groups	40.2	(4.4)
2.4. Conflicts and violence associated with these inequalities	36.2	(4.3)

The same reductionism appears in relation to the *possible causes of the Earth's degradation.* About 40% of science teachers denounce economic growth guided by individual interests in the short term as the foundation of the current degradation processes. This is an accurate evaluation, according to the analyses of the World Commission on Environment and Development (1987) or the Worldwatch Institute (Worldwatch Institute, 1984-2005).

But these problems are intimately related to other phenomena that should be considered as well. Firstly, we draw attention to the over-consumption in so-called "developed countries" and of dominant groups in each society (United Nations Development Programme, 1998, 2003 and 2005). A consumption that keeps growing as if the Earth's capacities were infinite is indefensible (Brown and Mitchell, 1998; Folch, 1998).

Secondly, it is necessary to put an end to the demographic explosion on a planet which has limited resources. Given the frequent resistance to accepting that a growing population poses a serious problem today, it seems convenient to present some data about its influence in relation to the present unsustainable rate of economic growth (World Commission on Environment and Development, 1987; Orr, 1994; Hubbert, 1993; Ehrlich and Ehrlich, 1990, 1993; Brown and Mitchell, 1998; Folch, 1998; Sartori & Mazzoleni, 2003):

- Since the second half of the 20th century, more human beings have been born than in the whole of humanity's history. As some authors have pointed out, very soon there will be as many people alive as deceased in all history; half of all human beings that have ever existed will be alive (Folch, 1998).
- The *present* population would need the resources of three Earths to generalise the standard of living of the developed countries (United Nations, 1997).
- Although the rate of population growth has diminished in recent times, the population increases every year by about 80 million and will double again in a few decades.

Such data have led Ehrlich and Ehrlich (1990) to affirm emphatically that, without any doubt, the demographic explosion will soon stop. What we do not know is whether the end will arrive gently, through a decrease in the birth rate, or tragically, through the growth of mortality. These authors add that demography is the most serious problem humanity has to

face today, given the time gap between the start of an appropriate programme and the beginning of population decline. Brown & Mitchell (1998) summarise the question by saying that population stabilisation is a fundamental requirement to halt the destruction of natural resources and guarantee the fulfilment of everyone's basic needs.

In short, over-consumption and the demographic explosion determine a type of economic growth that is extremely corrosive of the physical *and cultural* environment. Astonishingly, in our survey, science teachers do not seem to be aware of the importance of these two determining factors; only about 20% make any reference to demographic growth, and over-consumption is mentioned by less than 10% (!). Similarly, 29.9% of the science textbooks refer to over-consumption. This percentage rises to 33.1% for demographic growth.

The fact that most Europeans (including educators and politicians) see the current low birth rate as a problem rather than a positive trend, is quite illustrative of the near absence of values related to sustainability (Almenar, Bono and García, 1998). On the other hand, over-consumption in developed countries and the demographic explosion in others provoke serious inequalities. Billions of fellow humans are scarcely able to survive in undeveloped countries and large segments of the "first world" are excluded… while a fifth of the human population offers its high-consumption model (United Nations Development Programme, 1997 and 2003; Folch, 1998; Mayor Zaragoza, 2000).

Extreme poverty in undeveloped countries, which is a consequence of the demographic explosion and of the imposition of individual interests and values (through military conflicts or through the activities and speculation on behalf of trans-national enterprises which seek to avoid any democratic control) lead inexorably to an unsustainable exploitation of natural resources in a desperate attempt to pay back interest, satisfy external debts and gain some benefit. These inequalities and derived conflicts receive some attention in science teachers' responses to our survey (about 50% mention them). However, as we have already indicated, no relationship is established between these problems and over-consumption or demographic explosion. There seems to be a serious lack of understanding of the relevance of globalisation to the problems outlined. **Tables 4** and **5** summarise the results we have presented in this paragraph.

A holistic approach to the state of the world demands more than simply diagnosing the problems; it is also necessary for teachers to study the possible solutions to the planetary crisis described, in order to help their pupils to explore alternative approaches and to participate in actions aimed at favouring particular alternatives. Merely studying the problems provokes at best indignation and at worst despair (Hicks and Holden, 1995; Tilbury, 1995). It

is therefore necessary to answer two questions: *What positive measures can be adopted? And how much attention does science education pay to these measures?*

What positive measures can be adopted?

We can structure the different proposals made by researchers and institutions into the following three groups:

- *Technological* measures to better satisfy human needs without damaging the environment;
- *Educational* measures to make possible the necessary changes in personal values and life-style choices;
- *Political* measures on a planetary scale to avoid the imposition of individual interests and values that are harmful for other people or future generations.

Each of these measures is discussed in detail below.

Technological measures

There is general agreement over the need for technologies that favour sustainable development (Gore, 1992; Daly, 1991; Daly and Cobb, 1989; Flavin and Dunn, 1999; United Nations Development Programme, 2001). The proposed measures range from the search for new energy resources, through the improvement of efficiency in food production, the prevention of illnesses and catastrophes, to the reduction and recycling of waste. But what are the criteria for distinguishing when technology favours sustainable development? Daly (1991) suggests two obvious principles:

- Gathering rates of resources must not surpass regeneration rates (or, for resources that are not renewable, the creation of renewable substitutes).
- Waste production rates must be lower than the assimilation capacities of the ecosystems.

Additionally, Daly (ibid.) insists on the fact that we are moving from an economy of an *empty world* (where technology was the limiting factor for taking profit from the exploitation of natural resources) to an economy of a *full world,* where natural capital will increasingly become the limiting factor. In other words, the aim of technology for sustainable development must be to increase the efficiency of the resources, rather than raise their extraction rate. This means, for instance, that we need to invent more efficient lamps instead of constructing more electrical power stations.

About 30% of science teachers in service and 50% of science teachers in training refer to the need for these technological measures. Incidentally, this is one of the few aspects where

we find strong differences between teachers in training and in service. The percentage of science textbooks that refer to these technological measures is even higher (75.6%).

Although technology has an important role to play, it is necessary to question the widespread and erroneous idea that the solution to the serious problems which humanity has to face today depends solely on a better knowledge and on more advanced technologies: options and dilemmas are essentially matters of ethics (Tilbury, 1995). This conclusion directs us in part to the educational measures we have to consider.

Educational measures

About 60% of science teachers in service, 50% of science teachers in training and 59.1% of the science textbooks analysed signal the need for educational measures, in accordance with the recommendations of experts on sustainability (United Nations, 1992). It is in fact the only aspect with a high percentage in science education papers.

The educational measures proposed to contribute to a sustainable society place the emphasis on global analyses and solidarity (Delors, 1996; Morin, 1999; Vilches & Gil-Pérez, 2003). Such measures overcome the general tendency to attend to individual short term interests (or to follow habits that correspond to an 'empty' world of isolated compartments). We need an education that contributes to a correct perception of the state of the world and prepares citizens for decision-making (Aikenhead, 1985 and 1996), generating responsible attitudes and behaviours (Bybee, 1991; Fien, 1995; Tilbury, 1995; Mayor Zaragoza, 2000) oriented to the attainment of a culturally plural and physically sustainable development.

Questions like "What energy policy should be promoted?" or "What role should be given to genetic engineering in the food industry?" and "What controls on GM food production should be introduced?" demand informed decision-making and the adoption of suitable policies. We need an education that promotes responsible behaviours, not just favourable opinions and attitudes (Almenar, Bono and García, 1998; Vilches and Gil-Pérez, 2003).

Some authors have signalled that these responsible attitudes and behaviours cannot be attained without overcoming the usual anthropocentric stance that gives priority to human beings over the rest of nature (García, 1999). But in our opinion, it is not necessary to abandon an anthropocentric point of view to understand the necessity of protecting the environment and bio-diversity. Who could continue to promote the unsustainable exploitation of Nature after becoming aware of the serious dangers this entails for his or her *own* children?

We believe that an education for a sustainable society should be based on what can be reasonably understood by most people, even if their ethical values are more or less

anthropocentric. In other words, the borderline should be one that separates people who have, from people who lack, a sound perception of problems and an inclination to contribute to the necessary decision-making and actions. Such a perception should be enough to understand, for instance, that educating for a sustainable future is incompatible with aggressive publicity that stimulates unintelligent over-consumption, incompatible with simplistic and Manichean "explanations" that attribute any difficulty to "foreign enemies" and incompatible with the promotion of competitiveness, understood as a contest to achieve something at the expense of others who are pursuing the same objective (Vilches & Gil-Pérez, 2003).

It is necessary for such education to promote the analysis of conceptions that are presented as "obvious" and "unquestionable" without alternatives, thus obstructing the possibility of making choices. This is particularly the case with *competitiveness*. Everybody speaks of competitiveness as something that is absolutely necessary, without realising that it is a type of behaviour which is incompatible with the aim of sustainable development. In fact, the success of one person or group in a commercial battle implies the failure of others. This contradicts, we insist, the characteristics of sustainable development, which must necessarily be global and embrace the whole planet.

Instead of promoting competitiveness, we need education that helps students and teachers to analyse the efficiency of our actions from a global viewpoint, taking into account its repercussions in the short, medium and long term, both for ourselves and for the whole of humanity. We need education that helps to transform the current economic globalisation into a democratic and sustainable project (Delors, 1996) that enhances the richness of biological and cultural diversity. Nevertheless, it is quite frequent to hear doubts about the effectiveness of such education, "given that individual behaviours have a small influence on such big problems as, for instance, resource depletion or environmental degradation" (ibid.). These problems, it is affirmed, are basically provoked by large industries. But it is easy (very simple calculations are needed) to show that although an individual can only save a very small quantity of energy or materials, when these quantities are multiplied by millions of people, the amount that could be saved becomes quite large, with the consequent reduction in environmental pollution and degradation. In fact, appeals to individual responsibility are multiplying; they include detailed lists of possible concrete actions in different fields, ranging from water and food supply to traffic, from cleaning, heating and lighting to family planning (Button and Friends of the Earth, 1990; Silver and Vallely, 1998; The Earth Works Group, 2000; Riechmann, 2003).

These educational aims need to be incorporated into an appropriate educational framework which contemplates, among other measures, international, national and local curricula for the period of compulsory schooling, provision for adult education at all ages, in-service teacher training, etc. It is stressed that the aims of such a programme should be implemented across a range of school subjects, particularly at secondary level, not just through science education alone, however the latter is organised.

On the other hand, individual contributions can and must go beyond the private domain and extend to professional, social and political activities. They can support, for instance, non-governmental organisations and political parties that promote solidarity and environmental protection; they can also demand positive action on behalf of public institutions (town councils, parliaments). It is particularly necessary for individual and collective actions to avoid local or partial approaches and contemplate many-sided environmental questions (pollution, resources depletion…), and other related problems, such as social inequalities and conflicts, from a planetary perspective. The ecologists slogan "to think globally and to act locally" has its limitations; we now know that it is also necessary to *act globally* as well (O'Connor, 1992), by adopting *political measures on a planetary scale*, capable of avoiding the imposition of individual interests and values harmful for other people or for future generations. We comment on these in the next section.

Political measures

Unfortunately, only about 20% of science teachers in training or in service and 22% of science textbooks contemplate the need for political measures to guarantee the defence of the environment and life on Earth. Moreover, the discussion about the political measures that could promote sustainable development usually produces inflamed debates, but demands careful analyses. The adoption of planetary political measures is contemplated by most science teachers and citizens with scepticism and with a certain reluctance.

There is scepticism, because previous attempts have shown little effectiveness. Nevertheless, "radioactivity that knows no borders reminds us that we are living - for the first time in human history - in an interconnected civilisation that embraces the whole planet" (Havel, 1997). We can therefore understand the absolute necessity, also for the first time in human history, for political integration to put the environment, as the common substratum of life, above the economic interests of any country, region or trans-national enterprise.

We could think that the danger of only local approaches is disappearing because of the present vertiginous process of economic *globalisation*. Paradoxically, this process is not

global at all when it concerns the survival of life on our planet. As Naredo (1997) pointed out, "in spite of so much talking about globalisation, our approaches continue to be partial, sectorial and one-dimensional". We do not consider environmental destruction specifically… or rather we take it into account, but not in order to avoid it. Economic globalisation, explains Cassen (1997), "irresistibly pushes to displace production centres towards countries where ecological norms are less restrictive".

Economic globalisation thus appears to be quite one-dimensional. For this reason, planetary norms are necessary in order to avoid the general degradation of the environment and the economic cost, which has only just begun to be evaluated (Constanza et al., 1997). In this sense, political integration on a planetary scale is deemed absolutely necessary and *urgent*; this integration must be capable of promoting and controlling the measures to protect our social and physical environments before the degradation process becomes irreversible.

In short, a new world order is required, based on co-operation and solidarity, with institutions capable of avoiding the imposition of particular vested interests harmful to other people or to future generations (French, 1992; Renner, 1999; Cassen, 1997; Folch, 1998; Giddens, 1999; Sen, 1999; United Nations Development Programme, 2002). However, this planetary political integration, that our survival seems to depend on, also generates the fear of cultural homogenisation which is already in progress: that is to say, *the fear of cultural impoverishment*. But the destruction of cultures cannot be attributed to a process of political integration which has not yet occurred. It is just another consequence of purely commercial integration. A democratic order on a planetary scale could contemplate the protection of the environment and the defence of biological and cultural diversity, without excluding intercultural exchanges.

A fully democratic worldwide political integration constitutes, therefore, a prerequisite which will help stop the current physical and cultural planetary degradation. Sadly, as we have already indicated, only 20% of science teachers consider these kinds of measures to be necessary.

The collection of measures outlined so far appears to be associated with the need to universalise human rights. The next section is dedicated to clarifying this relationship.

Sustainable development and human rights

It may seem strange to establish such a direct relationship between human rights and sustainable development. In fact, only 6% of teachers in service and in training and just 1.6% of science textbooks consider that overcoming the current degradation processes and

inequalities is a question of human rights. For this reason, we shall try to clarify what is understood nowadays by *human rights*, a concept that has been growing and now contemplates three "generations" of rights (Vercher, 1998).

We can refer, firstly, to *democratic civil rights (opinion, association…) for everybody, without social, ethnic or gender limitations*. These constitute a condition *sine qua non* for citizens' decision-making about current and future environmental and social problems (Folch, 1998). They are known nowadays as "first generation human rights", because they were the first rights to be demanded and obtained (not without conflict) in a growing number of countries. In this respect, we must not forget that the 'Droits de l'Homme' from the French Revolution (to mention a wellknown example) explicitly excluded women, who only achieved the right to vote in France after the Second World War. Neither must we forget that such fundamental rights are systematically violated every day in many countries.

In the second place, we refer to *economic, social and cultural rights* or "second generation human rights" (Vercher, 1998; United Nations Development Programme, 2000), such as:

- The universal right to a satisfying job, overcoming insecure situations to which hundreds of millions of human beings (including more than 250 million children) are submitted;

- The universal right to an adequate dwelling in an appropriate physical and cultural milieu;

- The universal right to appropriate nourishment, both quantitatively (avoiding under-nourishment of billions of fellow humans) and qualitatively (avoiding unbalanced diets);

- The universal right to health. This requires resources, research and education in order to fight infectious illnesses (cholera, malaria…, that are still ravaging many third-world countries) and the new 'industrial' and behavioural illnesses (such as tumours, depressions, AIDS…). It is necessary, above all, to promote healthy milieus and habits as well as solidarity towards disadvantaged or handicapped people;

- The universal right to family planning and free enjoyment of sexuality (the only limitation being the freedom of others), overcoming the cultural and religious barriers that condemn millions of women to submission;

- The universal right to an education of quality, *throughout* one's life, without social, ethnic or gender limitations;

- The universal right to culture, in its broadest sense, as a supporting axis for personal and collective enrichment and development;

- The universal right to investigate any kind of subject (life's origin, genetic manipulation…) without ideological limitations (such as those which prohibited Galileo's

work), but with a suitable degree of social control. This control must take into consideration social and environmental consequences and prevent the hasty application of insufficiently tested technologies.

Finally, we refer to third-generation human rights, known as *solidarity rights* "because they tend to preserve the integrity of the whole population" (Vercher, 1998). They incorporate the right to life in a suitable environment, the right to peace and the right to sustainable development for all people and future generations:

- *The right of all human beings to an environment appropriate to their health and welfare.* As Vercher (1998) states, the incorporation of this right as a fundamental human right derives from an unquestionable fact: "if degradation of the environment continues at the current rate, maintaining it will soon be the most fundamental survival issue for everybody, everywhere… The later we recognise this situation, the greater the sacrifices and difficulties that will need to be overcome to achieve an appropriate recovery".

- *The right to peace,* which involves the prevention of individual or vested interests (economic, ethnic, cultural…) prevailing over general interests and values.

- *The right to sustainable economic and cultural development* of all peoples. This involves, on the one hand, the questioning of the present marked economic inequalities between different human groups and, on the other hand, the defence of cultural diversity and cultural crossbreeding (against racism and ethnic or social barriers).

Vercher insists on the fact that these third generation rights 'can only be achieved by the harmonious effort of all actors of the social scene'. We can therefore understand the link we have established between sustainable development and the universalisation of human rights. And we can also understand the need to proceed towards real globalisation, with democratic institutions on a planetary scale that are capable of guaranteeing this ensemble of rights.

The *ensemble* of these rights appears to be a requisite (and, at the same time, an objective) of a sustainable society, as *they are all interconnected*. We cannot conceive, for instance, the interruption of the demographic explosion without the recognition of the right to family planning and free enjoyment of sexuality… and these are connected also to the right to education.

In short, achieving sustainable development is synonymous with universalising human rights in their widest sense. This requires:

- creating democratic institutions, on a *planetary scale*, that are capable of preventing the imposition of individual interests that are harmful to other people or future generations;

- orienting scientific technological development towards the attainment of technologies that favour sustainable development;
- promoting education that is capable of countering the general tendency to behave according to individual short term interests.

Unfortunately, we note that most science teachers in our survey, as well as the textbooks, do not make any reference to human rights:

- only 6% of teachers (both in service or in training) consider that overcoming the current degradation processes and inequalities is a question of human rights;
- references to democratic civil rights are made by less than 2% of science teachers and less than 7% refer to rights of solidarity;
- the only rights that are mentioned by a significant percentage of science teachers – about 10% - are socio-economic.

Tables 6 and **7** summarise the results which relate to the foregoing matters.

Table 6. Attention of science teachers to the positive measures to be adopted.

Positive measures proposed	Teachers in service N= 327		Teachers In training N=521	
	%	(sd)	%	(sd)
3.1 Political measures on a planetary scale	19.9	(2.2)	17.9	(1.7)
3.2 Educational measures	63.9	(2.7)	52.4	(2.2)
3.3. Technological measures	31.5	(2.6)	50.3	(2.2)
4. Universalisation of human rights	6.1	(1.3)	5.8	(1.0)

4.1 Democratic civil rights	1.8	(0.7)	0.7	(0.4)
4.2 Economic, social and cultural rights	11.3	(1.8)	7.1	(1.1)
4.2.* The right, in particular, to investigate any kind of subject	13.1	(1.9)	22.3	(1.8)
4.3. Solidarity rights (the right to a healthy environment…)	6.7	(1.4)	5.1	(1.0)

Table7. Attention in science high school textbooks to the measures to be adopted

| Positive measures proposed	Science textbooks N = 138	
	%	(sd)
3.1 Political measures on a planetary scale	22.0	(3.7)
3.2 Educational measures	59.1	(4.2)
3.3. Technological measures	75.6	(3.8)
4. Universalisation of human rights	1.6	(1.1)
4.1 Democratic civil rights	1.6	(1.1)
4.2 Economic, social and cultural rights	3.9	(1.7)
4.2.* The right, in particular, to investigate any kind of subject	30.7	(4.1)
4.3. Solidarity rights (the right to a healthy environment…)	18.9	(3.5)

Conclusions and perspectives

Any attempt to confront the problems that affect human survival should contemplate *the ensemble* of challenges that we have pointed out. We have already shown that high percentages of science teachers and science textbooks ignore each of the aspects under study. In fact, the mean of the aspects identified by teachers in service and in training is, respectively, 4.7 and 4.9 (from a total of 19). This mean is 7.0 in science textbooks, far from the 19 aspects contemplated in our analysis network. The similarity of the results obtained from these different methods reinforces our finding that concern for the state of the planet is a
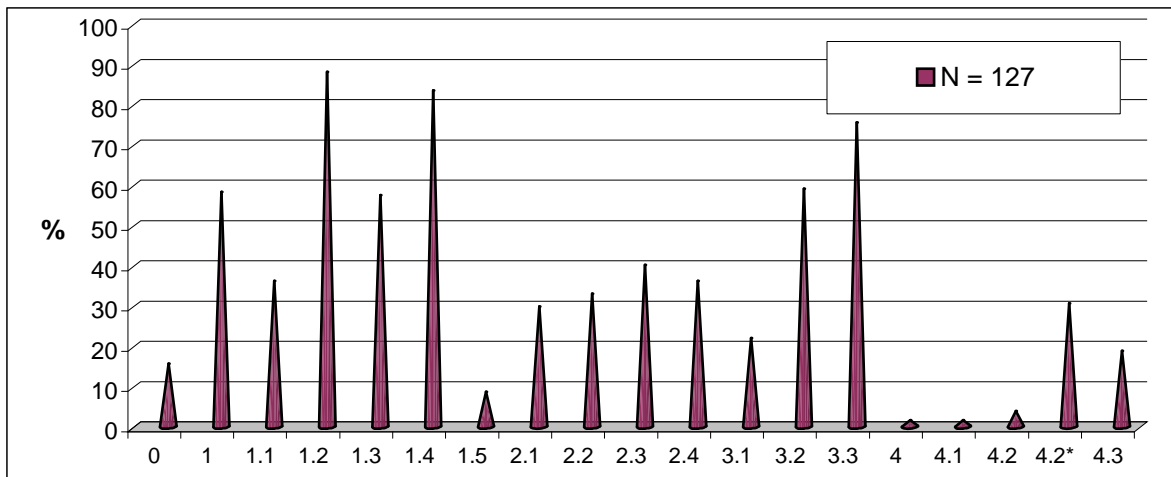
missing dimension in science education. **Figures 1** and **2** show this very clearly. They also reveal the reductionism of the perceptions of science educators and researchers.

Figure 1. Science teachers' perceptions about the state of the world

(The figures on the horizontal axis relate to the numbered items quoted in table 1)
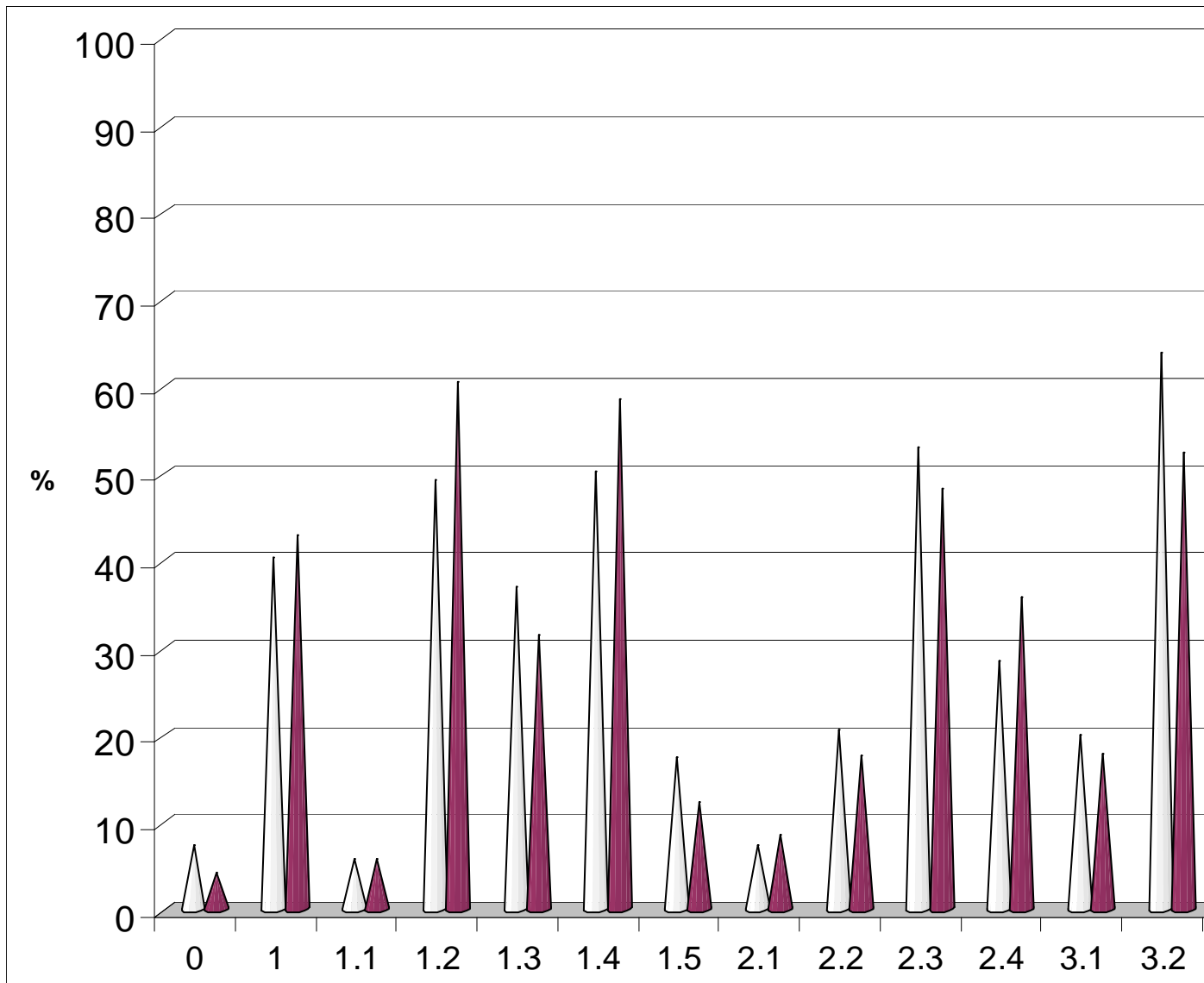
Figure 2. The attention of science textbooks to the state of the world

These results explain why we have referred to the state of the world as a missing dimension in science education. This dimension should be urgently incorporated if we want to answer the United Nations call to contribute to the Decade of Education for a Sustainable Future. We have already begun to implement workshops to facilitate the study of these problems by science teachers (Gil-Pérez et al., 2003; Edwards et al., 2004). Results obtained are quite encouraging, but more research and training is needed for this dimension to be effectively incorporated into the ordinary science curriculum.

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