Concept Mapping: Connecting Educators
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CONCEPT MAPS: TOOLS FOR UNDERSTANDING COMPLEX PROBLEMS

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Abstract. One of the major obstacles to effectively informing the public about complex problems is the lack of means to make such problems comprehensible. Global warming and nanotechnology are extraordinarily complex issues because they involve a great deal of highly specialised knowledge and also because it is difficult to perceive how they impact our daily lives. It is extremely challenging to create an adequate cognitive representation of these questions because of the tremendously large scale of one (global warming) and the exceedingly tiny scale (nanotechnology) of the other. In this work we propose using concept maps as a tool to communicate knowledge and facilitate understanding of these important subjects.

1 Introduction

Complexity is a broad concept that touches upon different aspects of how issues or problems are perceived. To begin with, we can accept that complexity arises from different sources. First of all, there is epistemological complexity linked to: being unaware of information that allows a problem to be understood; the seemingly random fluctuation of the real world caused by total or partial ignorance of the conditions that determine a result; situations that emerge when events that are not causally related interact with each other, and finally, the total or partial inability to evaluate effects provoked by all of the above. Secondly, there is a cognitive complexity involved in mentally representing problems.

The methods employed to disseminate information to the public about complex problems should provide scientifically valid information represented in a way that reduces epistemological complexity. At the same time these methods should be able to render the cognitive complexity of problems comprehensible. To accomplish this, links between scientific knowledge and common knowledge should be represented.

When modelling our examples we considered the sources of epistemological complexity mentioned above, as well the cognitive complexity arising from the inability to create a mental representation of knowledge objects that are either too large (global warming) or too small (nanotechnological products) to be perceived on a normal human scale.

2 Global Warming: the complexity of the very large.

Climate change is a process that involves variables related to nature. The interaction of these variables and the value that they adopt in each space-time moment determine the dynamics of the climate system. Anthropogenic activities have created disturbing trends in the dynamics of the current global climate. Consequently, in order to understand global warming we must consider not only natural variables, but also how they interact with variables related to human activity. From this perspective, the methods used to inform the public about global warming must be capable of managing a large amount of information related to different categories of variables and rendering the interactions between them comprehensible. This will allow cause-effect relationships to be established between variables that initially were far beyond common knowledge.

All concept maps are based on a theory. In our case we feel that natural and social systems are interdependent and that a great part of the complexity involved in global warming arises from this interdependence.

2.1 Representing the complexity of global warming

A map outlining the problem of global warming must tackle various sources of complexity. Complexity [1] caused by the magnitude of the problem; global warming overwhelms a subject's cognitive expectations because it involves a reality of extraordinary size. Complexity [2] related to the large number of variables interacting, which allow us to understand the cause-effect relationships and the different phenomena related to global climate change. Complexity [3] is also derived from the fragility of the system which is vulnerable to the fluctuating values of variables as they interact (values which determine the seemingly random behaviour of the system). Finally, [4] the specialised scientific knowledge about global climate change creates further complexity.

Because there are so many different sources of complexity interacting, this subject and knowledge system is difficult for the general public to understand. Our example presents a graphic visualisation of the basic expert knowledge related to global warming. By indicating the functional relationships, the concept map helps close the gap between how this subject is understood and how it is mentally represented.

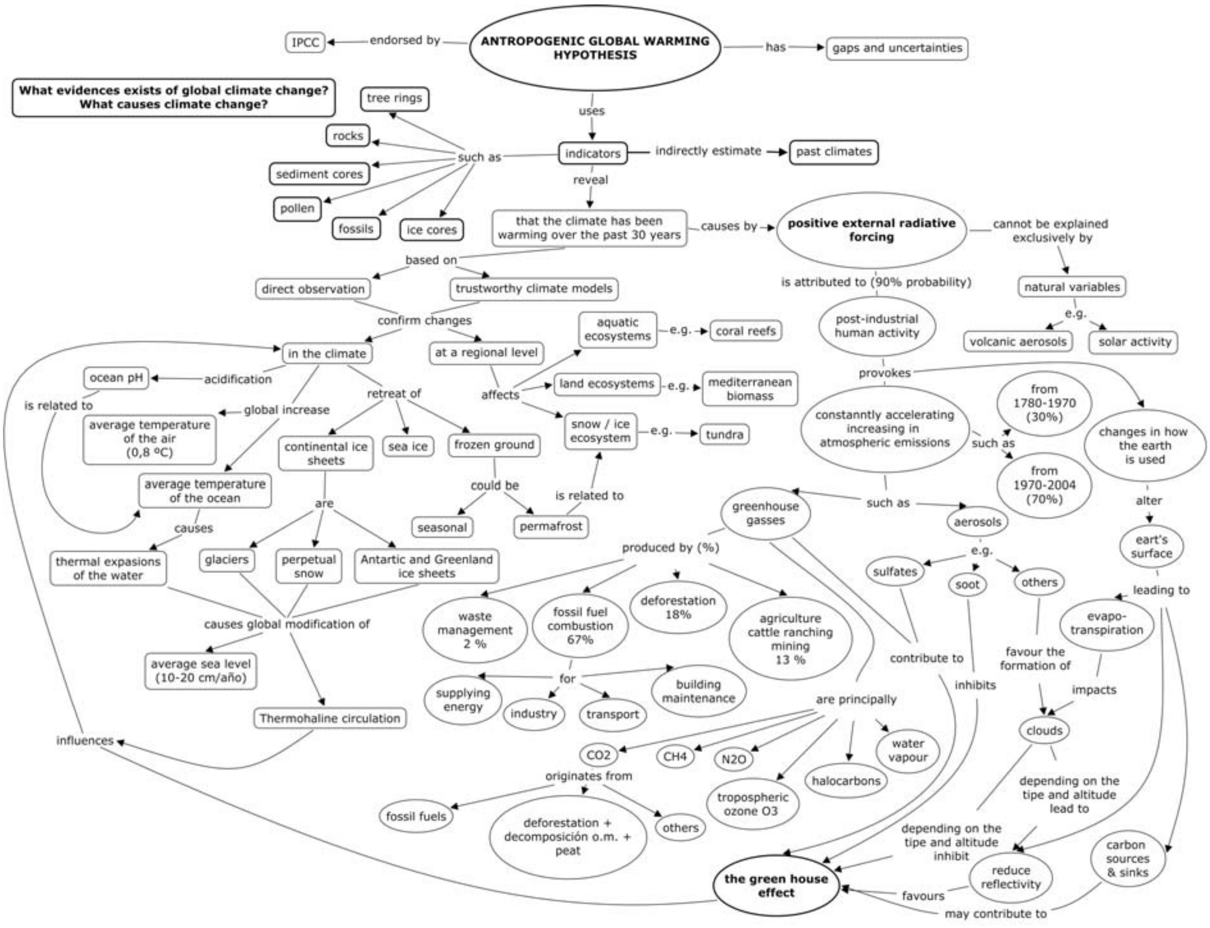

Figure 1. This is an example of the basic expert knowledge related to global warming.

3 Nanotechnology: complexity in an emerging world

Nanotechnology can be defined as applications derived from specialised knowledge of Materials Chemistry, Materials Physics and Molecular Biology. By applying this knowledge, nanotechnology can produce artificial objects that are so tiny that they are imperceptible to humans. These artificial nanoscale objects produce effects which can be perceived at the macroscopic scale through items we use in our daily lives.

Because nanotechnology is based on highly specialised knowledge that is not understood by the majority of the public, information about nanotechnological products and processes should be aimed at clarifying the fundamental concepts of the technology and facilitating a cognitive representation of the nanotechnological world.

3.1 Representing complexity through ordinary examples

Nanotechnology shares complexity sources [1] and [4] with the global warming problem and incorporates a new source of complexity: technologies that manipulate the physical world to create objects that do not occur naturally are always risky. The fact that current scientific literature does not completely describe how these newly developed objects will interact with those that already exist introduces uncertainty into our knowledge systems. This uncertainty makes it difficult to evaluate nanotechnology and, therefore, to decide whether to accept or reject it. Hence, in order to comprehend the complexity of the problem the benefits and risks involved must be understood.

To achieve this understanding, the specialised knowledge at the heart of nanotechnology must be linked to objects and processes that operate in environments that cannot be manipulated at the human scale, yet whose existence modifies the perceivable world. With this in mind our example represents nanotechnology from the point of view of familiar applications in the hope of evoking mental images of the technology and its relationship with specialised scientific knowledge that can be understood by the general public.

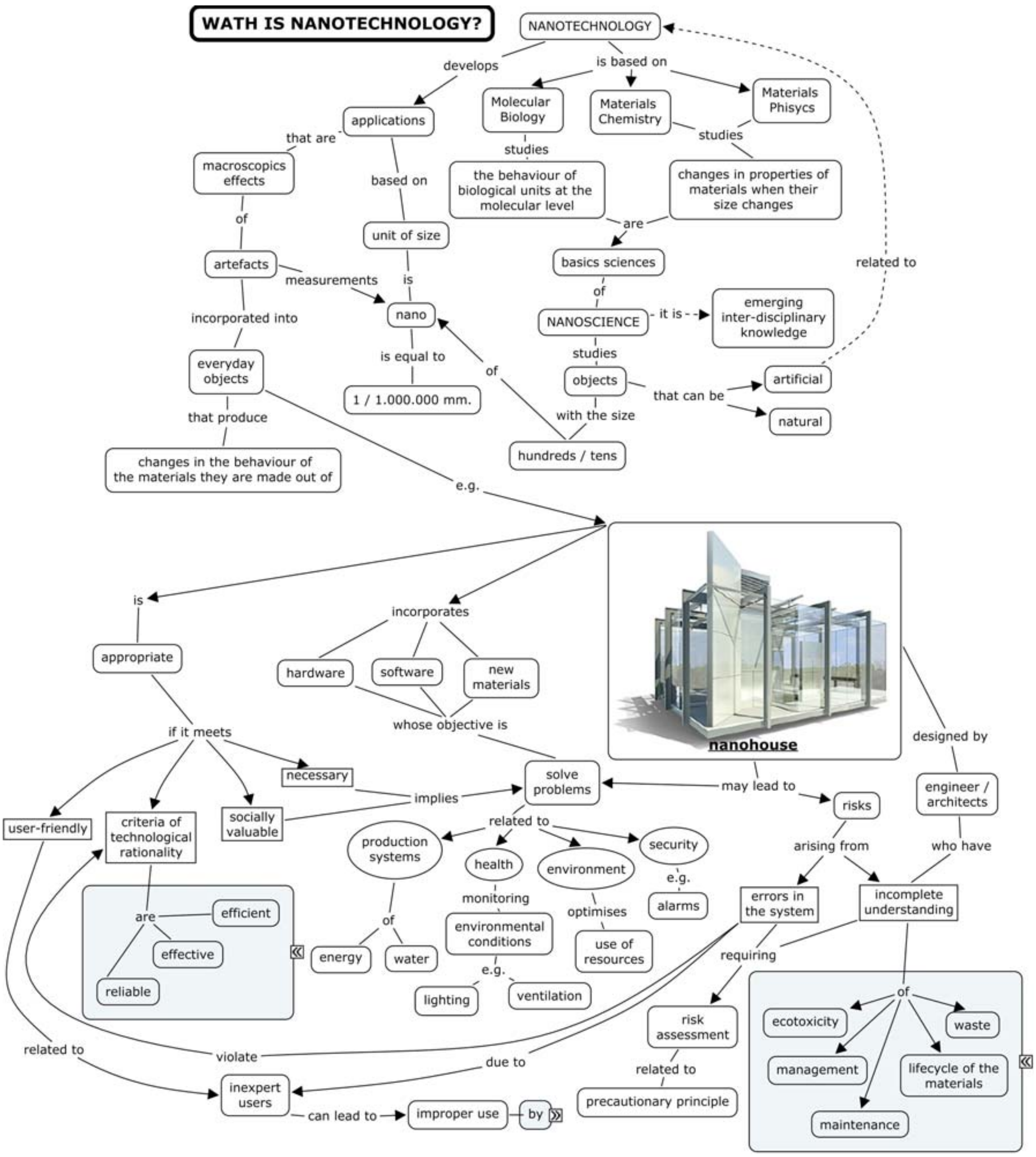

Figure 2. This is an example of the basic expert knowledge linked to everyday objects and processes.

4 Summary

We propose to involve concept maps in the public dissemination of scientific knowledge and technology. We have linked the use of concept maps to both the communication and comprehension of information by using iconic representation of specialised knowledge and evoking relationships between this knowledge and everyday life. Our initial hypothesis is that concept maps can be useful tools for communicating information to the general public about complex issues, as long as fundamental expert knowledge is represented and the sources of cognitive complexity related to the issues are minimised.

The examples that have been described are part of two projects designed to disseminate information. In the case of global warming, work is being carried out in secondary education to develop concept maps that allow students to acquire specialised knowledge by understanding the global dimensions of the problem.

The Project is currently in the experimental phase, with two groups of 16 year old students: a) a control group that, with little instruction, receives information by watching part of Al Gore's documentary "An inconvenient truth", which focuses on part of the problem by presenting information that is medium-highly difficult to understand. b) an experimental group which takes part in activities designed to contextualize the problem before (a conceptual questionnaire) and after (group discussion of a complex expert conceptual map which is divided into a group of simpler, interconnected maps) viewing the documentary. In order to minimize the possible "map shock" suggested by the TCU group, Gestalt principles are employed when organizing the complex information. In addition, using different iconic codes the students' preconceptions, the concepts in the video and concepts from other sources, some of which contain hyperlinks, are emphasized. Finally, both groups are given an evaluation questionnaire, which focuses on the comprehension of the new information, the acquisition of scientific knowledge and the application of this information to real situations that affect the students.

The nanotechnology example was borrowed from a project to disseminate scientific knowledge; this project seeks to facilitate understanding of this issue by constructing a conceptual framework, which gives meaning to the relationships between basic disciplines and everyday applications, within a more general framework of the Science, Technology and Society Programme.

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