Teaching of Energy Issues: A Debate Proposal for a Global Reorientation

JOSEP LLUIS DOMÉNECH1, DANIEL GIL-PÉREZ2, ALBERT GRAS-MARTÍ1, JENARO GUIVASOLA3, JOAQUÍN MARTÍNEZ-TORREGROSA1, JULIA SALINAS4, RICARDO TRUMPER5,7,*, PABLO VALDÉS6 and AMPARO VILCHES2,

1Universitat d’Alacant, Alacant, 03080, Spain; 2Universitat de València, València, Spain; 3Euskal Herriko Unibertsitatea, Universidad del País Vasco, Bilbao, Spain; 4Universidad Nacional de Tucumán, Tucumán, Argentina; 5University of Haifa, Haifa, 31905, Israel; 6Instituto Superior de Tecnologías y Ciencias Aplicadas, Ciudad Habana, Cuba; 7Kibbutz Hahoterim, Doar Na Hof Hacarmel, 30870, Israel (E-mail: rtrumper@research.haifa.ac.il)

Abstract. The growing awareness of serious difficulties in the learning of energy issues has produced a great deal of research, most of which is focused on specific conceptual aspects. In our opinion, the difficulties pointed out in the literature are interrelated and connected to other aspects (conceptual as well as procedural and axiological), which are not sufficiently taken into account in previous research. This paper aims to carry out a global analysis in order to avoid the more limited approaches that deal only with individual aspects. From this global analysis we have outlined 24 propositions that are put forward for debate to lay the foundations for a profound reorientation of the teaching of energy topics in upper high school courses, in order to facilitate a better scientific understanding of these topics, avoid many students’ misconceptions and enhance awareness of the current situation of planetary emergency.

Key words: Teaching energy, debate proposal, global reorientation

1. Introduction

There is a general agreement among science teachers on the importance of choosing the teaching of energy as a focus of interest in the science curriculum, since this is a central idea which provides an important key to our understanding of the way things happen in the physical, biological and technological world (Driver & Millar 1986).

Moreover, the slow and painstaking development of the concept of energy and the related concepts of heat and work is a marvellous example of how concepts and theories are built and evolve in science.

* This paper has been conceived as a contribution to the Decade of Education for Sustainable Development, established by the UN General Assembly for the period 2005–2014.
Furthermore, energy issues have personal, social and environmental implications that may help to enhance students’ interest in learning. Understanding these implications is necessary in order to make informed decisions concerning the current situation of planetary emergency (Bybee 1991). As a result of the seriousness of this situation, the United Nations has established a ‘Decade of Education for Sustainable Development’ from 2005 to 2014.

This agreement on the importance of a sound understanding of this field has been accompanied by growing awareness of the existence of serious learning difficulties, even among university students. This has stimulated a great amount of research and discussion about how to teach this field of knowledge.

Most of this research addressed specific conceptual aspects such as the confusion between force and energy, or the idea of energy as a substance (some kind of fuel) contained in objects, thanks to which changes may occur (Black & Solomon 1983; Watts 1983; Brook & Driver 1984; Brook 1986; Nicholls & Ogborne 1993). These learning difficulties gave rise, in the 1980s, to a wide debate about how to introduce energy into the curriculum (Duit 1981, 1986; Sexl 1981; Warren 1982; Hicks 1983; Solomon 1985).

This research, and the innovation derived from it, was associated, in general, with the conceptual-change learning model (Posner et al. 1982; Driver & Oldham 1985; Tobin et al. 1994; Duit 2004). This model proposed basically to elicit alternative conceptions and to create cognitive conflicts in pupils, generating dissatisfaction with their current ideas (Trumper 1997) and preparing them for the introduction of scientific conceptions.

The effectiveness of these conceptual-change strategies, compared to the simple transmission of knowledge, was supported by considerable research undertaken in different fields of science education. However, these also showed some limitations (Shuell 1987; White & Gunstone 1989). For this reason, researchers in the field of science education began to question the ‘reductionism’ of the conceptual-change proposals (Gil-Pérez & Carrascosa 1985; Hashweh 1986). Duschl and Gitomer (1991) criticized the hierarchical view of conceptual-change, which assumes that changes in central commitments to a theory of science bring simultaneous changes to other ontological, methodological and axiological commitments within the conceptual framework: “if we are to produce radical restructuring of concepts, the personal correlate of Kuhn’s revolutionary science, then it seems that we must also teach the procedural knowledge involved” (Duschl and Gitomer 1991, p. 847).

In other words, it is necessary to pay attention to how students reason (Gil-Pérez & Carrascosa 1985; DiSessa 1993).

It also began to be understood that the construction of knowledge has axiological commitments and, in sum, that we cannot ignore the strong links of the conceptual, procedural and axiological dimensions of science