Energy in Education: Editorial

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Teaching and learning about energy at the various levels of school science has been a topic of interest in science education research for nearly five decades. This interest has been motivated by the need to help students appreciate energy-related, socio-scientific issues and formulate appropriate and informed stances and attitudes. The emphasis placed on teaching energy could be interpreted as a response to the oil and energy crises that have played an important role in this period. This has led to various teaching innovations for addressing the conceptual and cultural aspects of energy as a scientific construct (for examples see, Agabra et al., 1979; Falk & Hermann, 1981; Haber-Schaim, 1983). At the same time, the interest in energy by the science education research community is reflected by the significant and diverse studies that have been published on students' ideas about energy, students' ability to reason with energy as well as the formulation of corresponding teaching proposals (e.g., Driver & Millar, 1985; Solomon, 1992; Duit & Haeussler, 1994; Tiberghien, 1996).

Until today, energy remains a topic of intensive research in science education. One reason for this is again the increasingly influential role of issues relating to the management of energy resources, which in turn creates a need for helping students become better positioned to appreciate and understand the ongoing discourse (e.g., Millar, 2005; Intelligent Energy, 2009). This interest is reflected in the focus currently placed on energy at various levels, including collective networks of researchers (such as the GIREP Thematic Group on Energy - http://www2.fisica.uniud.it/urdud/index.htm) as well as individual research groups. This has often led to the formulation of research questions concerning the historical and epistemological status of energy in

school science (e.g., Kaper & Goedhart, 2002; Coelho, 2009), the re-appraisal of how to introduce energy in school science so as to facilitate a more functional understanding of energy (Domenech et al., 2007), the possibility of introducing energy at an early stage (Koliopoulos, 2012) or the perceptions of teachers about energy teaching and the development of programs for teacher preparation and professional development (Pinto, 2005). This volume is intended to contribute to the ongoing discussion within the science education research community about the priorities and constraints of teaching energy.

The special issue consists of five articles, which, we believe, could serve a productive and generative role in the wider discussion on teaching and learning about energy. Coelho, revisits the issue of the historical roots of the energy conservation principle (Kuhn, 1977; Garcia, 1987). Based on the original papers of the inventors of energy (Mayer, Joule, Colding, Helmholtz), he argues that in their perspective, their work was not about formulating a fundamental quantity; they did not emphasize the indestructibility or transformability of energy. Rather, they worked on establishing equivalences between different domains, such as motion and heat, motion and electricity or position and motion. Coelho takes the position that the idea of equivalence could provide a useful framework for helping students overcome some of the conceptual problems encountered in teaching elaborations of energy. It is important to note that this study addresses the important issue of how to undertake qualitative teaching elaboration of energy while maintaining epistemological validity. We believe that this issue is of relevance, explicitly or implicitly, to all studies included in this issue.

Colonnese, Stefanel, Santi, Heron and Michelini address the issue of the vertical elaboration of energy in school science, from the elementary to the high school grade level. Even though the idea of energy as a broad thematic topic or as an organizing framework for the science/physics curriculum has appeared in teaching proposals very early (70's and 80's), it is seldom utilized in conventional teaching about energy. In their article, the authors propose a vertically integrated, research-based approach to teaching energy in primary, middle and upper secondary schools. A common theme that runs through all these grade levels is the notion of energy being converted from one form to another. This idea appears in a qualitative manner at the primary grade levels and it gradually incorporates quantitative aspects in subsequent grades. The authors report on ideas related to the classroom implementation of the various teaching modules they have developed.

The next two studies focus on an important issue, which often does not receive adequate attention: the extent to which a conceptual approach to energy could be usefully coupled with epistemological aspects or with issues relevant to the methodological aspects of the natural sciences. Hammer, Goldberg and Fargason seek

to address this issue by focusing on the ideas of a 'responsive curriculum' and 'responsive teaching'. They draw on data from the discourse that takes place in a third-grade class (conversations between pupils or between teacher and pupils) and they provide evidence of children's conceptual or epistemological resources that could be productive for developing an understanding of energy. The main thrust of the argument advanced in this study is that this approach allows teachers to ensure a productive teaching and learning context that could help students develop both, conceptual understanding but also an appreciation of the epistemic aspects of science as a domain of human activity. Papadouris and Constantinou, on the other hand, report empirical findings from the enactment of a philosophically-informed teaching proposal about energy at the middle school. This proposal seeks to shift away from a conceptually-oriented approach towards a philosophically-informed perspective. The empirical results suggest significant learning gains in students' understanding. For instance, one of the main findings relates to the marked improvement in students' appreciation of the trans-phenomenological and unifying nature of energy. This is an important aspect of energy as a construct, which, however, is commonly ignored by conventional teaching.

Finally, Vince and Tiberghien focus on the connection between the teaching of energy and topical energy-based, socio-scientific issues. This study presents design tools that could facilitate the design of teaching and learning materials that could address both, issues relevant to teaching about energy and the nature and characteristics of the social challenges inherent in the corresponding socio-scientific issues. These design tools enable a shift towards a teaching paradigm that extends beyond the conceptual aspect. It addresses the possibility of formulating teaching transpositions of scientific content and practices that transcend the relationships between society, technology and science.

The significance of energy in science and technology and also its relevance to topical socio-scientific issues are likely to sustain the present educational emphasis on the topic of energy. The ongoing discussion on teaching and learning about energy introduces an additional dimension. It illustrates the complexity of teaching and learning as a generative process that needs to take into consideration epistemological, epistemic, conceptual and community parameters if it is to effectively engage young people in meaningful interactions.

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