

Visual and gestural metaphors for introducing energy to student teachers of primary school and kindergarten levels

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Abstract. In this contribution we present an animated movie narrating a story that introduces us to the force of nature and the roles of potentials, energy carriers, and energy in physical processes. It uses visual metaphors for making roles clear. The movie is used in a physics course for student teachers of primary school and kindergarten levels. Visual metaphors are used for analyzing processes from the point of view of the power of forces of nature, and energy flows and exchanges. In a laboratory accompanying the course, students are requested to explore a toy, and design and interpret a play about the physical processes in the toy where they are the energy carriers that interact and exchange energy, and energy is embodied as confetti.

Conceptual metaphor theory constitutes an excellent point of view for studying conceptualizations scientists, students, and lay people create when interpreting physical processes and the role of energy in such processes [1-6].

Visual metaphors allow us to create an imaginative approach to macroscopic systems and processes, including the energy principle, as they are formally conceptualized in continuum physics [7]. Formally speaking, the power of a process is related to tensions (potential differences) and flows of fluid-like quantities (volume of fluid, quantity of electric charge, entropy, momentum, etc.). Power is quantified by the rate at which energy is made *available* or *used*. This is a generalized version of Carnot's image of the waterfall driving a water wheel that serves as an analogy to how a heat engine functions [8]. Moreover, energy can be transferred: it accompanies conductive, radiative, and convective transfers of the fluid-like quantities. Third, energy can be stored. Finally, energy is conserved.

The energy principle takes the same form in every branch of classical physics. It is not considered the determinant of a particular process; rather, in continuum physics, it is used to put restrictions upon concrete forms of constitutive relations. Put more prosaically, we need to understand the underlying fluid-like quantities and their potentials (and potential differences) if we want to describe phenomena and apply the concept of energy.

This approach to physical processes and energy has been rendered with the help of visual metaphors in a short animated story created by an art student at the School of the Arts in Zurich [9]. In the story where an inventor attempts to create a perpetuum mobile consisting of a lamp, a solar cell, electric water pump, water wheel and generator feeding back to the lamp, fluid-like quantities are symbolized as spirits that carry and hand over dust (energy) as the processes in the machine are running. As the perpetuum mobile must necessarily fail, the story develops into a well-crafted allegory of the Earth as an open flow system.

In this contribution we will present the use of this animation in a physics course offered to student teachers of primary school and kindergarten levels in the master degree program in Primary Education at the Department of Education and Humanities at the University of Modena and Reggio Emilia in Italy. The story is shown during the lectures when the concept

of energy is introduced. Students learn how to analyze processes from the point of view of energy flows and exchanges, and to distinguish between energy and energy carriers. In the laboratory part, after the lectures, they are requested to explore a toy, and design and interpret a play about physical processes in the toy where they are the energy carriers that interact and exchange energy, embodied as confetti.

Acknowledgment

The authors kindly acknowledge the permission given by Marion Deichmann to use her animated movie for educational purposes.

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