THE MLE-ENERGY SOFTWARE FOR ENERGY CHAIN MODELLING

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Abstract

MLE-Energy is an elementary modeling software for energy chain construction of natural processes crated for primary and middle school pupils, to initiate them in model-centered learning. This tool, created in Flash platform to be used on interactive whiteboard is proposed as one of the various didactical materials produced within the project "Little scientists in the lab: Experiments & Models for science learning in primary school". This project, funded by the Ministry of Italian Education proposes a model-centered learning environment to build pilot activities, based on experimental and modeling approaches.

1. Introduction

Modeling is an important means to develop a scientific approach to problems since it helps students to get used to identify the relevant variables and the relations between them, formulating hypotheses, and designing experiments suitable to explore and prove such hypotheses (Gilbert and Boulter, 2000). MLE-Energy uses symbolic icons to represent energy carriers and energy exchangers and guides the user in constructing the energy chain by means of some rules and the request of writing labels. In this contribution we present the software and some preliminary results of experimentation during training courses for in service teachers.

The project "Little scientists in the lab: Experiments & Models for science learning in primary school" takes the lead from a specific approach to physics teaching. It takes inspiration from the Continuum Physics Paradigm (CPP) and its various didactical applications, as developed by Hans Fuchs (Fuchs H., 1997) as well as from the Karlsruher Physikkurs (KPK) developed by Friedrich Hermann (Hermann et al., 2006). The CPP views physical processes as the result of the flow, the production, and the storage of certain physical quantities such as charge, entropy, momentum, amount of substance, and every other quantity which satisfy laws of balance. This approach underlines the structural analogy of different phenomena and forms the basis of the unification of different fields of physics. Moreover, viewing quantities as quasi-substances, it provides powerful mental images, which will form a network upon which students will build future understanding. The KPK is a comprehensive secondary school level physics course. Key to the KPK approach to physics education is energy, as a "transversal" entity, able to create a connection between the various fields of physics and others science disciplines (biology, chemistry, geology etc.) (Hestenes, 2009). KPK moves away from the traditional definition of the "forms of energy" to label the various combinations of quantities representing the different appearances of energy. There is no talk of energy transformation, but only of energy that flows with and among carriers. This vision of energy, the identification of substance-like (extensive) quantities as opposed to intensive quantities and their relation built upon an equation of continuity, all create a powerful learning environment based on the use of analogies among different fields.

Although not oriented to primary instruction, KPK is promising for its very unitary and comprehensible view of the whole discipline. However the approach should be adapted to be suitable for primary school such as: contents simplification and didactical tools design are the path to take. Our goal is evolving in both directions. This paper presents a part of a modeling software tool to analyze energy flow.

2. The project "Little scientists in the lab: Experiments & Models for science learning in primary school"

The project aims to transfer some of the approaches of KPK and CPP into primary school instruction.

Innovative tools and learning paths are part of the project. The team has designed experiments for class use and multimedia tools such as animations, a website and a modeling software to support personal and group understanding of phenomena.
At primary school level, pupils are starting to learn mathematical bases. At this school level mathematical formalization does not matter for thinking in science. Rather it is the deep understanding of connections and relations between physical quantities that should be underlined. Such task can be favored by the construction of a shared language, based on simple keywords, corresponding to basic physical concepts. The MLE modeling software, which is a part of the project, moves in this direction.

3. The software MLE-Energy

Most of the modeling software are tailored for secondary school students. They are feasible only for learners with the corresponding mathematical background. Thus, they are too complicated to be used by primary school pupils. Moreover they rely on mathematical relations between physical quantities instead of focusing on the properties of the physical quantities themselves.
MLE-Energy allows designing energy flow diagrams, using carriers and exchangers as “building bricks”. It is only one of the components of the wider MLE modeling software, developed within the project, that will include tools for analysis and dynamic interpretation of processes. It is an iconographic, easy to use, straightforward program, designed for primary school teachers and pupils. It is feasible both for personal use and group discussions both on PC and in class on the interactive whiteboard.
It is a true modeling software, not a childish game, just as feasible for children aged 6 – 10 as for secondary school students because it can be employed with different degrees of complexity. Students, during their career, will deepen their understanding of science creating energy flow diagrams of growing complexity and basing their new exploration on past works. Each diagram will become a brick for further ones. All these characteristics help developing and systematizing mental images of processes, by allowing personal exploration of phenomena followed by model sharing.
An additional feature of MLE-Energy is that it has been developed in Adobe Flash and it can run on any operative system.

4. How the software works

The working environment mimics a notebook with some objects represented by icons placed on the right side (figure 1).

Figure 1: working environment

Icon description appears on the top box when the user moves the mouse over one of them, while on click the enlarged version of the icons appears in the “New object” box. From there, objects can be dragged and positioned throughout the board. All interactions can be done on click and drag. No precise positioning is required since objects are automatically anchored at the board grid.

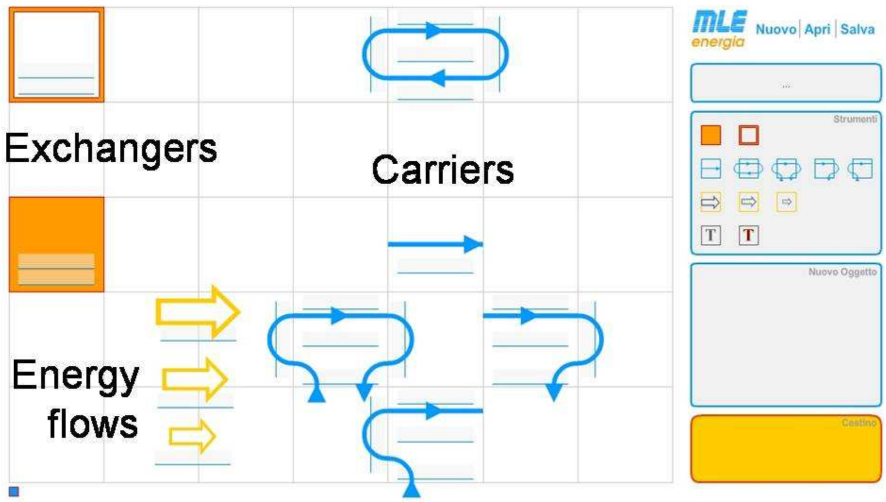

Figure 2: available icons with description

Orange boxes represent *energy exchangers* (figure 2). Each one is a sort of “black box”, a symbolic representation. Users focus on what comes in and what goes out of it. The program requests to label each exchanger helping the user to identify which object it represents. In a typical energy model, each exchanger decreases the incoming carriers’ potential and increases the potential of the outgoing ones.

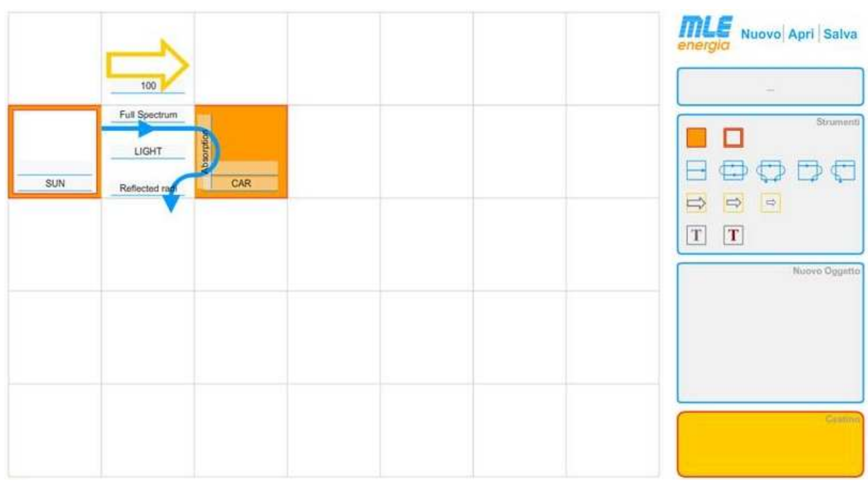

Figure 3: elementary energy diagram

Blue arrows represent *energy carriers* (figure 2) of different kinds, thus the user can choose among close and open circuit carriers of five types. Besides choosing the type of carrier, the user is invited

to name it and define its low and high potential levels. Two more labels allow indicating the processes of increase and of decrease of the carrier potential.
Thicker yellow arrows provide for an image of *energy flux* (figure 2). Labels can be used to indicate the energy quotes entering into and exiting from each exchanger from a conservation point of view.
Text labels can be added and positioned freely within the grid.
All objects can be rotated by steps of 90 degrees with double clicks of the mouse.
The carriers, both incoming and outgoing, can be linked to other exchangers producing an energy flow diagram (figure 3). They can be extended by adding elements before and/or after and by expanding an element into a more analytical representation (figure 4).

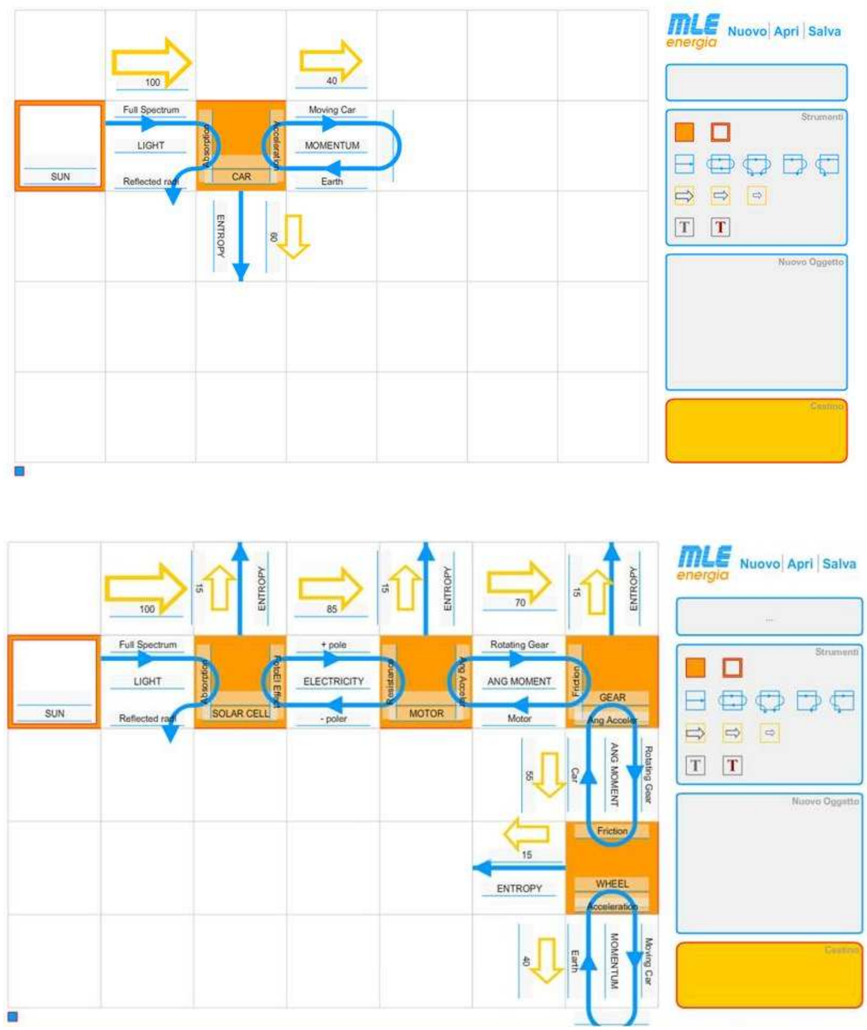

Figure 4: (top) energy diagram extended with two more carriers; (bottom) complex energy diagram

5. Didactical Implications

We have experimented MLE-energy during a pilot phase of the project “Little scientists in the lab: Experiments & Models for science learning in primary school” that took place in the first half of 2009 in different Italian districts. About 200 in-service teachers went through a 14-hours training. Through interviews and discussions, both with the teachers and within the research team, the following didactical potentialities of the software emerged.

- MLE-Energy has the typical flexibility of software. File can be shared, compared, modified, combined and inserted in ever complex chains. The same flexibility is extremely useful for teachers as well. They can develop learning paths, share and refine them. Sending their work to experts from university, they can easily obtain confirmation and help.

- Easy to use, it favors free use without fear of committing mistakes. All components can be dragged, switched, turned and combined according to thoughts evolution. Yet, the structure itself imposes certain elementary rules which can offer help for model design. Choosing among different icons and labeling forces the clarification of models and the appropriation of subject specific language.

- Used on the interactive whiteboard, it favors cooperation and discussion both in small scale and full class groups.

- It is a learning tool. It is coherent with KPK approach in so far as it focuses on energy transfers relating it to quantities defined as energy carriers and identifying potential difference as cause of these transfers. Through its use students and teachers develop and reinforce the interpretation of a wide range of phenomena by means of the only two concepts of exchanger and carrier.

- It reinforces the vision of the universal principle of energy conservation. The definition of an “energy source” or an “energy receiver” is merely arbitrary and it becomes soon obvious that the chain can be extended further backwards or forwards. We can also analyze a process in a more detailed way by “blowing up” the inside of each box and envisioning the energy chains there embodied.

- It is a vertical curriculum tool since it can be employed in experimentation from primary school all the way through secondary school and further, at different levels of complexity and deepening.

- Analyzing processes at different levels of details is useful to help students with learning disabilities, by clarifying relations visually.

These considerations suggest possible enhancements to the software as extending the existing working area and available components, possibly to model dynamically the processes and further developments

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