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DYNAMIC MODELLING WITH "MLE-ENERGY DYNAMIC" FOR PRIMARY SCHOOL

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Abstract
During the recent years simulation and modelling are growing instances in science education. In primary school, however, the main use of software is the simulation, due to the lack of modelling software tools specially designed to fit/accomplish the needs of primary education. In particular primary school teachers need to use simulation in a framework that is both consistent and simple enough to be understandable by children (Corni et al., 2010). One of the possible area to approach modelling is about the construction of the concept of energy, in particular for what concerns the relations among substance, potential, power (Fuchs, 2007).
Following the previous initial research results with this approach (Corni et al., 2010), and with the static version of the software MLE Energy (Corni et al., 2009), we suggest the design and the experimentation of a dynamic modelling software - *MLE dynamic* - capable to represent dynamically the relations occurring when two substance-like quantities exchange energy, modifying their potential.
By means of this software the user can graphically choose the dependent and independent variables and leave the other parameters fixed.
The software has been initially evaluated, during a course of science education with a group of primary school teachers-to-be, to test the ability of the software to improve teachers' way of thinking in terms of substance-like quantities and their effects (graphical representation of the extensive, intensive variables and their mutual relations); moreover, the software has been tested with a group of primary school teachers, asking their opinion about the software didactical relevance in the class work.

1. Introduction

During the recent years simulation and modelling are growing instances in science education. Modelling activity is useful to construct a language among students and teacher, to develop the ability to deal with variables, to design experiments, to interpret the results. These are abilities usually associated with secondary school sicence education curriculum, so the software are designed to accomplish the needs of students with a deeper mathematical grounding. In primary school, the main use of software is the simulation, which is an easier way to work with variables and their relations, without the need to deal with the definition of the model in which the varialbles are related. Often the simulation software for primary school are performing a single task and are useful as a substitution or an integration of the experimental activity. This approach can lead to a non-coherent design of activities, as the primary school teacher often doesn't have a theoretical framework in which the activities can be placed. For this reason we suggest that the teacher needs to develop the ability to build and test simple models of phenomena, which can be successively experimented in the class activity.
Today we observe the lack of modelling software tools specially designed to fit/accomplish the needs of primary education. In particular primary school teachers need to use modelling and simulation in a framework that is both consistent and simple enough to be understandable by children (Corni et al., 2010).
One of the possible approach to modelling is the construction of the concept of energy, in particular for what concerns the relations among substance, potential, power (Fuchs, 2007).
Following the previous initial research results with this approach (Corni et al., 2010), and with the static version of the software MLE Energy (Corni et al., 2009), we suggest the design and the experimentation of a dynamic modelling software - *MLE dynamic* - capable to represent dynamically the relations occurring when two substance-like quantities exchange energy, modifying their potential.

Modeling energy transfer processes is a possible activity to introduce primary school teachers and children

Energy transfer processes are a suitable starting point for simple modeling activities in primary school, as energy is an important subject in the primary school curriculum which is often approached in a simplified and descriptive way: energy in different forms, "transformation" of energy, renewable and disposable energy forms, etc.

Instead, our approach considers the construction of the concept of energy: the relations among substance, potential, power (Fuchs, 2007) are the foundation of energy concept. Starting with simple phenomena in which energy is transferred from an "energy carrier" to another. Every energy carrier has two aspects: a substance-like quantity (extensive quantity) and a conjugated quality, or potential (intensive quantity). Combining the two aspects of quantity and quality we have an effect which can be assimilated with power or "force".

As a starting point, static modeling of energy transfer processes is useful both for pupils and for teachers (Corni et al., 2009), as they can discuss and interpret the observed phenomena using the symbolic representation provided by the software as a language, helping to develop a more accurate use of common words.

Although useful, static modeling has a series of limitations in use: shows its limits in particular when the model needs to be verified (primary school teacher's competence is often not sufficient to predict the behavior of the model and this can lead to misunderstanding among children).

Another critical aspect connected with static modeling is the lack of quantitative information: to be effective and to guarantee a comprehension of the cause and effect relation between input and output, energy transfer needs to be quantified, at least showing the relation of direct and inverse proportionality between variables.

2. Dynamic modelling software for primary school

At the present there are no modeling software designed for primary school, and the availability of dynamical modeling software although not specifically designed but at least suitable for primary school is very little.

We discarded software such as Stella (ISEE Systems) or Coach (CMA), in which the model has to be expressed by means of formulas and the relations are represented in graphical form, because in this case the poor mathematical grounding of the teacher represents a problem. Other software make use of graphical representation of simple mathematical relations, such as VnR (Variables and Relations, by Ian Lawrence). This software can be suitable for teachers but it can be difficult in the everyday use, as it reduces the relations between physical quantities to mathematical relations, leading teachers to think in terms of mathematical relations (with some critical aspects) rather than relation among physical quantities (Corni et al, 2007).

At last, software like Junior Simulation Insight (Logotron) or Modeling Space (…) present a graphical representation acts dynamically, driven by variables, which constitute the mathematical model.

Although Junior Simulation Insight is very good for simulation (it has a very comprehensive collection of simulations, from different contexts and well related with the primary school curriculum), the interface and the functions of the software are quite complex. Moreover, modeling is difficult for primary school teachers, due to their poor mathematical abilities.

Our proposal is to develop a simple modeling software, to let the teacher model simple energy transfer processes. Teachers will be able to predict the behavior of simple energy transfer processes (what happens when a variable changes); to verify the relation between cause and effect (causation); to verify the behavior of everyday life processes. In this way, teachers will be able to design experiments or exploration activities and to assist pupils during the design of the experimental activities.

3. Features of MLE dynamic software

According with the Force Dynamic Gestalt approach (Fuchs, 2007) and previous research results (Corni, 2009), we propose a software to model a single "device" and two energy carriers, one incoming and one outgoing. Each of the two carrier has two aspects: a substance-like quantity (extensive variable) and a conjugated quality or potential (intensive variable). According with Image schema theory (Johnson, 1987) and Interface design theory (Hurtienne and Blessing, 2007) in the software each variable is represented with a slider: horizontal for quantity, vertical for intensity.

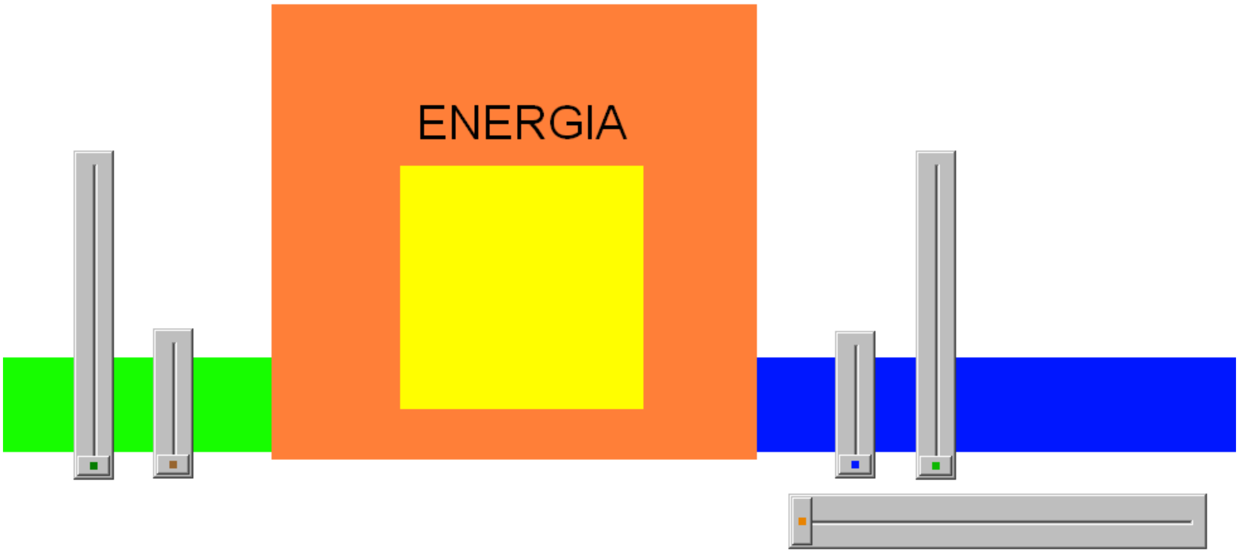

Fig 1: MLE Dynamic

The interface of the software is abstract, requesting the user to assign to each of the four variables its name and its meaning. Our proposal is a sort of “abstract simulation”. It has the characteristics of simulation, because it allows to predict the behavior and to verify hypotheses, but it does not present a graphical representation of the simulated phenomenon, so we can say that it is a simulation, although with abstract representation. The model on which the simulation relies on is a simple relation among four variables, two for the incoming carrier and two for the outgoing one, so it is Qin x ΔVin = Qout x ΔV2out, where Q is the quantitative variable and ΔV is the difference of potential.
Teachers are guided by a worksheet in the analysis of the process of energy transfer, following some steps: identify the relevant variables: substance-like / extensive quantity and conjugated intensity/intensive quantity
both incoming and outgoing from a “device”
Teachers decide which is the dependent variable, choosing the relevant model among four (the dependent variable can be one of the four variables), then they decide two more variables (parameters) which have to be set and remain fixed, and finallyhey increase or decrease the independent variable and see the corresponding variation of the dependent one.
The area of the yellow square labeled “energy” represents the total amount of energy transferred during the process
It is useful to focus on the role of energy in the transferring process: to change the amount of transferred energy it is necessary to change one of the two incoming variables. Changing one of the outgoing variables affects the other outgoing one, with no change in the total amount of energy transferred. Otherwhile we can change one of of the incoming variables, changing the total amount of energy transferred.

4. Conclusions

Abstract representation is useful to help the teachers to focus on the relevant variables, i.e. “building” the model. It helps to develop a general model, which is more suitable to interpret phenomena in different contexts. The relations among the variables are clear and unambiguous if the “choice algorithm” is followed carefully (by means of a guide worksheet). Abstract representation does not help to refer to the concrete and relevAnt aspects of the observed phenomena, so it would be useful a label or a iconic explanation of every variable.

In the beginning it is important to understand the basic behavior of the device and the relevant variables (it's impossible to build a model without thinking about cause and effect process). After the initial comprehension of the observed phenomenon, the software is helpful to formalize the behavior under different circumstances and in different situations. The software shows its limits when representing currents expressed with discrete quantities (such as number of sharpened pencils with a mechanical pencil sharpener, or number of sacks of flour produced by a windmill) Further improvements in the software will let the user, when uses the simulation, to remember the choices made, including some iconic elements: labels for the four variables; an icon for "fixed" variables (parameters); a text field, in which the question(s) posed by the user, and to which the model they answer, can be written using natural language; iconic representation of the energy carriers (moving flames, charges, drops of water …) with different colors to indicate their different potentials

At the moment the MLE-Dynamic software graphical interface is context-independent, with no iconic reference to the real appearance or symbolic representation of the substance: water, electricity, motion, etc., have the same representation. This is useful to improve the teachers' ability to develop models which are independent from the context, but it is not suitable for children. In the future we are introducing the possibility to characterize every carrier with its iconic representation.

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