Models and Simulations. Construction of a Theoretically Grounded Analytic Instrument

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Abstract

How teachers understand models and modeling have been the subject of many papers in Science Education research in recent years. Very little have been said about how teachers relate their understanding of models and simulations, even though being capable of evaluating simulations is a necessary skill for any teachers working with ICT technologies, due to the use of these in instruction and learning. In this paper we try to build up an analytic instrument to help teachers to have a critical appraisal of simulations. Its development has been based in the theoretical study of the ontological constituents of scientific models and in the nature of entities of the correspondent model object.

Introduction. Aim of the paper.

Models and Modelling had been the subject of many of papers along the last years in Science Education research. Many of these papers have focused mainly on how teachers understand models ([1], [2]) and/or modelling ([3] [4]). But it is hard to find papers that relate the issue of teachers' understanding models and computer simulations. It has been reported that frequently teachers do not use simulation software in the most adequate way and even that it is very common for teachers not to be very critical in the analysis of real/virtual nature of what appeared represented in the computer screen [5], [6]. We think that this situation is due mainly to a lack of critical analysis of the knowledge teachers already possess. The aim of this paper is to present a theoretically grounded instrument, capable of facilitating to the teachers the critical analysis of computer simulations, by linking this with the critical analysis of models.

1 Models and Simulations

A computer simulation[13] is defined usually as "the running of a model" [7]. A Scientific simulation is, then, the running of a scientific model. Our interest is on simulation software used to teach scientific subjects, that is, simulations based on scientific models. Thus, we need a definition of what a scientific models is. When we look for such definitions in Science Education literature, the issue is not a very easy task: Most of the authors do not define "scientific model", but they offer lists of its characteristics (i.e. Smit [8] enumerates twelfth, and Gilbert et al [9] eleven). This amount of distinctiveness is not very helping when trying to analyze the running of a model. The only way of simplifying is focusing on the essential, that is, the ontology of a scientific model. From here we can deduce the main categories for the analysis of models.

2 Ontology of scientific models

Bunge offers a study of this kind. We will try to simplify its philosophical terms, maintaining the necessary precision.

Methodologically he differentiate between *model object* and *theoretical model*:

-A *model object* is a schematic representation of the real or conjectured system". It lists the outstanding properties of an object of a given species. Example: A neutral pion is a particle with mass 135 MeV and half life 10^{-16} sec, that decay mostly into two gamma photons.

-A model object together with a set of law statements is a *theoretical model* [a scientific model] of the real or conjectured system. Example: a stochastic learning model [10 p 59, 60], [11 p 99].

From that we can conclude what the **ontological constituents** of a scientific model are:

-A *set of entities* (model object) with their specific properties fully expressed; and

-A *set of law statements* that declare the relationship between those entities.

2.1 Kind of entities

From an ontological point of view, there exist only two kinds of entities or objects:

-*Concrete objects,* or "real" things, such as a table. They have material structure and physical properties, as weight or colour;

[13] From now on, "computer simulation" will be referred to in the text as "simulation".

-*Constructs*, or formal objects, which are creation of human mind, like concepts or propositions. They do not have physical properties: they do move around, have not energy and no causal efficacy [12, p 116-117],

By definition, a **model object** is a construct, which may *represent*

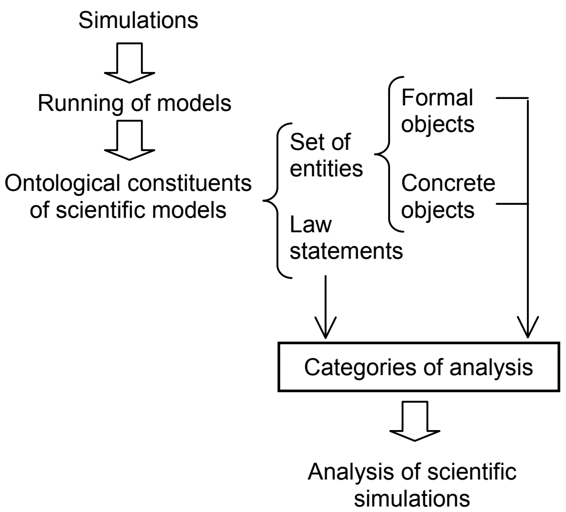
-Concrete objects: when *the concepts have their referents in the physical or factual world*, such as the concept of table; or

-Formal objects: *when the concepts have their referents in the formal world* (mathematics, logic, semantic), such as the concept of number [13]

From here we can obtain others important categories for the analysis of models: If they have their referents in the concrete, or in the formal world. These features determine if we are dealing with models that represent the physical world, or the formal world.

3 A theoretically grounded instrument for the analysis of simulations

As a result of our study, we have obtained a very simple theoretically grounded instrument, capable of facilitating critical analysis of scientific simulations. The Figure below sketches the categories of analysis and their relationships.



4 Discussion

It seems clear that the final categories for analyzing simulation software above shown are theoretically grounded, and economic in number. But it may appear that they are too abstracts to be easily understood by teachers. We are carrying out a pilot study to see how teachers understand this terminology, without having been previously introduced to it. Our first results lead us to believe that teachers can answer questionnaires using these terms. In a future paper we will report on the results of this study.

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