Models in E-Learning Systems

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INTRODUCTION

Models are everywhere. Terms like "modeling" and "model" are part of everyday language. Even in research, no overall valid definition of what a model is exists. Different scientific fields work with different models. Usually, the term "model" is used intuitively to describe something which is sort of "abstract". This is a rather vague concept, but all models have in common that they are abstractions in a broad sense and that they are developed for a certain purpose, for example, for testing and investigating parts of reality, theories or hypotheses, for communication, or for reuse. In e-learning the notion of models is frequently used in a rather naive and uncritical way. The main purpose of developing models seems to be lost in the overwhelming amount of available models. A situation has emerged where the development of a new special purpose model often seems to be much easier than the reuse, validation, or revision of existing ones.

In the following section approaches to define the term "model" will be sketched to provide a (historical) background in relation with computer science. Afterwards, an overview over existing models and different approaches to categorize e-learning models will be given. A future trend suggests a new categorization of e-learning models. The chapter closes with a conclusion.

BACKGROUND

In the 17th century the ancient Italian term *modello* became famous in fine arts. In contrast to its former narrow sense, nowadays the term is part of everyday language. "Models can be developed based on natural artifacts or things, on hypotheses, on theories, or even based on pure fiction. The modern interpretation of model is: the object which is the result of a construction process" (Martens, in press). However, the broad usage of the notion of model makes it difficult to exactly define the term. Mueller summarizes: "Each definition of 'model' is insufficient: It covers only a small range of the reach of use" (Mueller, 2005). Accordingly, the aim of the following sketch is not to give a definition of the term model, but to describe some perspectives on models and characteristics of models. Model is a cross-disciplinary concept – moreover, most models are inherently crossdisciplinary. Generally, models have in common that they are abstractions and interpretations. A model abstracts parts of the real world, or it sketches something new, which did not exist before. The model is always a summary of the main aspects of an original, as it abstracts from special parts and only takes into account what can be perceived as the generalization. Mathematically spoken, a model is a subset of a set of originals. Thus, a model is also a simplification and a reduction on the parts which are the most important for the model developer. As a model is an interpretation, the modeler's viewpoint, intention, and the purpose of the model also influence the model. A simple example might be the model of an ape—the designer of toy apes will use a completely different model of an ape than a scientist investigating ape behavior. Mueller (2005) describes the basic meaning of the term model as: "A model is a simplified part of reality or potentiality. It can be material or idealistic, graphic or abstract and describes a has-been, actual or future state". Stachowiak (1973) has summarized this in the three main characteristics of models, which are representation, reduction, and pragmatics. The *representation characteristic* of a model means that each model represents an original. This does not mean that a model must have its counterpart in reality (or the physical world). The original of a model can also be an assumption, a hypothesis, a theory, or a product of fantasy. The *reduction characteristic* implies that the model's attributes are a real subset of the attributes of the original. A model never comprises all attributes of the original. The *pragmatic characteristic* is that the model's purpose is to replace the original in a certain context, for example, to answer questions, for investigations, experiments, or under certain conditions.

Several different sources, for example, Flechsig (1983), Ludewig (2002), Mueller (2005), Reihlen (1997), and Troitsch (1990), agree about at least two perspectives on models. Models can bee seen alternatively as reproduction or representational interpretation of something (*descriptive model*), or as prescriptive interpretation of something (*prescriptive model*). This distinction focuses on two different perspectives of model development, that is, the model's background and the model's purpose. A *descriptive model* reproduces or represents a part of the real world; it is always based on an original. The model depicts something existing; it is a description and abstraction. The purpose of such a model is to document, to facilitate, to show, to allow for communication, etc. Instead of describing part of reality, *prescriptive models* describe something new, which does not exist before the model. The model itself is used to construct the original and not vice versa. A classical example for such

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a model would be Charles Babbage's difference engine.

Ludewig (2002) describes yet another type of model, which he called the *transient model*. This model starts as a descriptive model which is modified and changed, and finally becomes a prescriptive model, as it not necessarily has a counterpart in reality any longer. This situation can be found if a state in the real world should be changed, but the modification might be dangerous or irreversible. Then a process might be to start with a descriptive model of the state, perform the modifications on the model (which changes the descriptive to a prescriptive model) and perform tests and experiments on the model. Later, the modifications might be applied to the state in the real world. Such a situation is a classical modeling and simulation situation.

In modeling and simulation, modeling is necessarily a part of research (see e.g., (Troitsch, 1990; Zeigler, Praehofer & Kim, 2000). Modeling and simulation is – roughly spoken – used to investigate existing or artificial systems (von Bertalanffy, 1969). The investigation takes place based on experiments performed on models of these systems. Thus, if someone wants to investigate an existing or to develop an artificial system, he usually starts with the design of a model of such a system. Some steps are required before the model can be designed, which are system identification, definition of the level of abstraction (e.g., system border, level of detail), definition of the model's purpose (e.g., investigate, experiment, teach), and decision about the model representation or the modeling language. All these steps influence how the model is designed, and how the model can be used, reused, and validated. After executing some experiments, the model is usually validated and probably refined or redesigned.

MODELS IN E-LEARNING SYSTEMS

Looking at e-learning, a large amount of different models can be found. Examples are student models (e.g., Wei, Moritz, Parvez & Blank, 2005), evaluation models (e.g., Daniel & Mohan, 2004), cognitive models (e.g., Schroeder, Moebus & Pitschke, 1995), expert knowledge models (e.g., Seitz et al, 1999), process models (e.g., Martens, 2005), and data models (e.g., LOM, 2002). These models are described in different ways, for example, graphical, formal, or verbal. Some of the models are based on modeling languages, old ones like the language of mathematic and newer ones, like the UML (Unified Modeling Language) (e.g., Booch, Rumbaugh & Jacobson, 1999). In some research papers, even the notion of metamodels occurs (e.g., Grob, Bensberg & Dewanto, 2005).

Baker (2000) has made an approach to describe roles of models in Artificial Intelligence and Education (AIED). He distinguishes between three major roles: models in AIED are used as scientific tools, as components or as basis for design. He observed that currently, these different roles of models are mixed. As Baker's distinction does no help to structure e-learning models, another approach is chosen. To structure the amount of models described earlier, Stachowiak's (1973) three characteristics can be taken into account. Optimally, for each model the model developer should explain in advance what the model represents, where abstraction took place, and what the model's purpose is. In this context, three different categories for e-learning models can be suggested: models for e-learning system development, educational models, and models of the application domain. *Models for e-learning system development* include standards (e.g., LOM, 2002), formal models like the Tutoring Process Model (e.g., Martens, 2005) or patterns (e.g., Harrer & Martens, 2006; Harrer & Martens, 2007), and software engineering models (e.g., Pawlowski, 2000). These models are used to represent (computer based) e-learning system. They abstract from the programming and realization of the e-learning program. The purpose of the models is to provide for content and implementation independent descriptions and to facilitate communication about (technical) parts, structure, and relations in the designed e-learning program. *Educational models* either have a pedagogical background or are related to educational research, for example, investigation of human learning and behavior, like cognitive models (e.g ACT-R, described at Anderson & ACT Research Group, 2001). They can for example represent theories of learning, pedagogy, and didactic. Necessarily they abstract from real human behavior in teaching and training situations. The purpose is again support in system design and communication about realization and evaluation of learning approaches which underlie e-learning systems, but on another level then the system development level. *Models of the application domain* are related to the teaching and training field. The models represent the knowledge structures on which the teaching and training content is based (e.g., Illmann, Martens, Seitzet al., 1999). However, they abstract from details. They are used to provide for content independent descriptions of the teaching and training material, and – again – are used as a basis for system design and communication about content independent knowledge structures, relations, and adaptation possibilities. An additional category might be *design models*, which are related with the HCI development (Human Computer Interfaces) and research in this area.

The distinction between descriptive, prescriptive and transient, as described in the previous section, can be applied on the three categories of models. In e-learning, *descriptive models* can be for example data models like (LOM, 2002), which document and thus help to facilitate the reproduction of learning materials. Usually, descriptive models in e-learning are models of the application domain (as sketched above), which are used for teaching and training. Unfortunately, these models are seldom communicated or made explicit, but they are implicitly represented in the way teaching and training

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