Simulation in Teaching and Training

Alke Martens
University of Rostock, Germany

INTRODUCTION

Simulation has always been about learning. For being able to simulate something, a model of a system must be developed. Thus, the perspective of teaching and training with modeling and simulation is necessarily twofold. Sometimes the model builders are the primary learners. They learn by constructing models of scratch, and by changing model parameters. Sometimes the users of the simulation models are the target learners. They learn by interacting with a simulation. Sometimes, the learners are not aware that they interact with a simulation.

Applications are manifold and can stem from such diverse teaching and training domains as, for example, physics (Rickel & Johnson, 1999, 2002), computer science (Martens & Uhrmacher, 2001), psychology (Künzel & Hämmer, 2006), medicine (Kinshuk, Oppermann, Rashev, & Simm, 1998; Kühnapfel, Çakmak, & Maaß, 1999; Shaw, Ganeshan, & Johnson, 1999), aviation (Dörr, Schiefele, & Kubbat, 2000), and also military training (McGlynn & Starr, 2001; Moon, Schneider, & Carley, 2006).

Teaching and training in modeling and simulations overlaps with research in intelligent tutoring systems (ITS) (Atolagbe & Hlupic, 1997). In combining modeling and simulation with ITS, the ITS knowledge bases can be used for either steering the simulation run (Stottler, Jensen, Pike, & Bingham, 2002), providing the information for the models to be simulated (Martens & Himmelspach, 2005), or for giving advice and feedback (Bravo, van Joolingen, & de Jong, 2006; Stottler et al., 2002). A simulation can also be a part of a teaching and training system, instead of being the complete teaching and training system itself. This can take place by integrating additional simulated actors in a role-play, as pedagogical agents (Rickel & Johnson, 2002), or by simulating the environment (Dörr et al., 2000; Kühnapfel et al., 1999). This is also true for game-based approaches (Siemer & Angelides, 1994).

Sometimes the teaching and training system is designed in a way that mimics a real-life situation without actually simulating something in the sense of "execution of a model." Examples of such systems, which are also called simulations, can be found in areas like medicine. A classical example is the "simulation" of a patient case (Zary, Johnson, Boberg, & Fors, 2006).

Last but not least, models and simulations can be used as part of the design phase of a teaching and training system. Examples would be introducing and simulating learner models for testing tutoring software, and development of models in the context of teaching and training systems (e.g., software models, didactical models, learner models, etc.). As models in teaching and training systems are manifold, this aspect will not be pursued further in this article.

BACKGROUND

In recent years, the term *simulation* has become part of everyday language. Unfortunately, this goes hand in hand with blurring its scientific meaning. In everyday language, simulation is often used in the sense of "the act or process of pretending," or as "imitation or enactment." In the medical or psychiatric sense, simulation is related to feigning. Here it means the (conscious) "attempt to feign some mental or physical disorder to escape punishment or to gain a desired objective" (simulation, 2007). The term simulation has its roots in the Latin term for imitation: *simulationem*. The term *emulation* (in the sense of imitating something), which is closely related to simulation, and which also plays a role in teaching and training, will not be discussed in this article (for further reference, see e.g., emulation, 2007).

Simulation of something always requires some sort of *model*. Even in the medical sense, the person feigning a disease needs at least a basic concept, that is, a model, of the disease. The term *model* can be traced back to the 17th century, when the ancient Italian term *modello* became famous in fine arts. In the common sense, a model is an image of reality. Nowadays, the usage of the term is extended. 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. However, everyday language use of the term model is manifold; no single definition exists (see e.g., model, 2007).

From the perspective of computer science, a third term occurs in the context of modeling and simulation: the term *system*. A simulation in the context of science is sketched as: "the representation of the behavior or characteristics of one system through the use of another system" (simulation, 2007). Similar definitions can be found in the works of Zeigler, Praehofer, and Kim (2000) and Cellier (1991). The first system mentioned in the quotation is related to a fictitious or real system. This system shall be investigated. Usually there exists a hypothesis or a scientific question, which is the basis of an experiment. Often, experiments on real systems are not possible or not sensible. Reasons are that the experiment would take too long, would include too much risk, would simply not be possible, or the system is not available in real life. Thus, an abstract image of the system is required: a model. This model can then be simulated using another system, for example, the computer.

Unfortunately, in teaching and training research (and also in modeling and simulation) often a clear separation between model and simulation is missing. Nonetheless, models and simulations should be perceived to be different parts, that is, a model representing a system (and potentially an experiment) (Minsky, 1965), and a simulation is used to experiment with the system's representation (i.e., the model) (Cellier, 1991; Zeigler et al., 2000).

SIMULATION IN EDUCATION

There have been many attempts to categorize the large amount of simulations that can be found in educational settings. Min (1995) distinguishes simulations at the level of "what is simulated," that is, conversation, behavior, moving pictures, and phenomena. Boyle (1997) differentiates between three levels of required learner activity, that is, passive, exploration, and task-based. King (2000) tries to reduce these attempts to a common denominator: "Computer simulation is a form of learning with computers in which the user may experiment with a simulated situation." Another distinction has been

made by Feldstein (2004), who investigated authoring tools for simulations. In the context of learning objects, ASTD and SmartForce (2002) found that simulations are a kind of practice object, where the learner has the possibility to apply knowledge and skills in close to real world environments. They distinguish between different kinds of simulations, such as role-play, software, hardware, and coding simulations. Additionally, they found conceptual simulations, where the learner trains decision making, and business-modeling simulations (see ASTD & SmartForce, 2002). From a top level view, all of these simulation related practice objects represent either training content (i.e., hardware, software, coding, business-modeling) or special types of training (i.e., role-play, conceptual). Training content is related to a certain application area, whereas types of training could be better perceived as underlying learning theories or didactical and pedagogical strategies.

From the perspective of modeling and simulation in computer science, it is more interesting to investigate how models and simulations are used in teaching and training. Three different approaches can be distinguished: interactive modeling and simulation, character simulations, and demonstrative simulations. This distinction abstracts from the training content, learning theories, and underlying pedagogical or didactical strategies. The three types of simulations will be described in the following.

INTERACTIVE MODELING AND SIMULATION

In the interactive modeling and simulation the "system to be taught becomes the subject to be modeled and simulated" (Martens & Uhrmacher, 1999). Interactive modeling and simulation systems comprise every kind of simulation where in the process of training the learner somehow interacts with a modeled and simulated system (Smith, 1999). The behavior of a certain system will be represented to provide for a safe, challenging, and close to real life teaching and training environment. The basis of the interactive modeling and simulation is a model of a system. The learner's task can be to interact with the complete simulated system or to learn something about the system itself by investigating the model. Accordingly, interactive modeling and simulation can be further divided into interactive simulation and interactive modeling.

Related Content

Designing Scholarly Conversations to Promote Cognitive Presence and Knowledge Building: An Exploratory Study From an Online Graduate Course

Qijie Cai (2021). *International Journal of Online Pedagogy and Course Design (pp. 16-30).*

www.irma-international.org/article/designing-scholarly-conversations-to-promote-cognitive-presence-and-knowledge-building/274318

The Acrobatics of Flipping: Reorienting the Learning Experience of the First Accounting Course

David Starr-Glass (2015). *Implementation and Critical Assessment of the Flipped Classroom Experience (pp. 74-98).*

www.irma-international.org/chapter/the-acrobatics-of-flipping/123923

Does Online Outshine?: Online vs. Campus-Based Degree Withdrawal and Completion Rates within an MBA Program

Belinda Patterson, William Mallettand Cheryl McFadden (2012). *International Journal of Online Pedagogy and Course Design (pp. 53-64).*

www.irma-international.org/article/does-online-outshine/61400

Course Model Redesign for Continuity of Instruction

Elizabeth A. Sheaffer, Katie Boydand Cheryl D. Cropp (2022). *Handbook of Research on Updating and Innovating Health Professions Education: Post-Pandemic Perspectives (pp. 118-138).*

www.irma-international.org/chapter/course-model-redesign-for-continuity-of-instruction/288479

Computer Application Software Training via E-Learning

Jun Hu (2008). *Handbook of Research on Instructional Systems and Technology (pp. 571-581).*

www.irma-international.org/chapter/computer-application-software-training-via/20814