Guest Editorial: The Use of Simulation in Learning and Teaching

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THE FOCUS OF THIS SPECIAL ISSUE is training in problem solving and decision making. Many real problems are difficult to solve due to their sheer size or a lack of information that leads to uncertainty and their dynamic nature. Difficult-to-solve problems can be analyzed by an appropriate model. A model is a simplified presentation of reality. By making simplifying assumptions it is possible to develop a model of the problem which is easy enough to understand and analyze, and yet provide a good presentation of the real problem. In many cases these models can be incorporated into games or simulations to enhance the learning process.

Grieshop [1] proposes that games and simulations based on modeling reality are increasingly important for use in decision making, training and education in several domains. These activities range from role playing to problem solving and may include guided fantasy and case studies. Grieshop lists some of the benefits of games and simulations:

1) Emphasize questioning over answering on the part of players.
2) Provide opportunities to examine critically the assumptions and implications that underlie various decisions.
3) Exposing the nature of problems and possible solution paths.
4) Create an environment for learning that generates discovery learning.
5) Promoting skills in communicating, role-taking problem solving, leading, and decision making.
6) Motivation and interest in a subject matter are increased.
7) Evidence is offered for increased retention, energizing the learning process and facilitating the understanding of relationships between areas within a subject.
8) Focus of the gaming/simulation approach is on the process of learning rather than on end products (that is, actual decisions), and on representing the reality of a situation.

Beyond their uses in the military and the social sciences, gaming and simulation have been used for training in a variety of management fields such as quality [2], supply chain management [3] and process re-engineering [4, 5]. Along with implementation of simulations for education and training, there have been efforts to expand empirical research on the effectiveness of this approach [6–9].

Simulators and educational games model reality by making simplifying assumptions. The fidelity of a simulator is a measure of its deviation from the real situation; it has three dimensions: perceptual, functional and model fidelity. Perceptual fidelity refers to the level of realism it evokes in terms of its look and feel relative to the real system. Functional fidelity refers to the way users or trainees use and control the simulation, its behavior and responses to user actions. Finally, model fidelity refers to the extent to which the mathematical or logical model underlying the simulation is close to the real processes and phenomena [10].

The purpose of this special issue has been to assess the current state of the art in using simulations and games in engineering education and continuing professional development of engineers. The papers represent the best of over 50 submissions. They consider a variety of problems that are envisaged by different types of models. The number and diversity of articles demonstrate the pevasiveness of a large variety of simulation-based courses from different engineering schools. We believe this is indicative of an increasingly recognized need to teach and have students learn in situations which are closer to real life, that is to have a higher fidelity in the learning and teaching context.

The fidelity of simulators discussed in this special issue varies as well as the type of models used to represent the real situation. The results reported in all the papers are encouraging—with proper modeling, simulators are efficient and effective tools for training. The designer of a simulator must address the questions of what kind of model to use and what level of fidelity to apply in a specific situation. The collection of papers considers a variety of problems that are modeled by different types of models. The fidelity of simulators discussed varies as much as the type of models used to represent the real situation. We do hope that the collection of papers will help the designer of training simulators to improve the design and consequently to increase the efficiency and effectiveness of the simulators they develop.

From the standpoint of learning and teaching, the papers also vary in their emphasis when discussing the use of the simulator in learning, with some papers talking about the simulation developed for educational use and providing primarily case study evidence for the role of simulation in learning. Other papers look at a simulation and and then more closely examine the empirical research data which support the idea that the simulation has been an effective teaching/learning tool for the faculty and the students. This latter characteristic is one which we believe should be emphasized in future developments.

To this end, further testing of the educational and training value of simulations should be motivated in equal part by a concern with assessing the cognitive impact on learning and motivation. Some conceptual basis and guidance for this can be found in the work of Ausubel [11–13]. The fundamental notion of learning promoted by him is that learning takes place by assimilation of new concepts and propositions into existing networks of concepts and propositional relationships among concepts. Thus, in working with mature individuals, it is necessary to consider both the existing cognitive knowledge structures and the target structures we wish to have the learner establish. Ausubel identifies three conditions for meaningful learning to take place. First, the to be learned material should be conceptually clear and presented using language and examples which the learner is able to relate to existing knowledge in the head. Second, quite obviously the learner must posses the relevant prior knowledge. Third, the learner must be motivated to choose to learn meaningfully rather than through attempting simple memorization.

This clearly implies that the teacher/simulation designer should develop a clear sense of what existing knowledge the student brings to the situation, figure out a way to translate the new knowledge into terms, representations and examples that connect to existing knowledge, and develop pedagogical strategies which help to motivate the student to engage in meaningful learning rather than rote memorization.

Note that this also means that lectures and exploratory discovery learning methods can both promote meaningful learning and that neither is guaranteed in and of itself to be effective if Ausubel's three conditions have not been satisfactorily met. In either case it is necessary to know the starting knowledge of the student to enable the relating of new to old knowledge, to have conceptually clear language and examples which relate the new and old knowledge, and to motivate the student to engage in discovering/constructing new knowledge structures.

All of this implies that one direction for future empircal assessments of the effects of simulation and gaming on learning and training could well continue the trends embedded in some of the papers presented here, i.e. an assessment and discussion which knowledge the student is assumed to have at the atart, a statement of how and why the designer/simulation designer made the simplifying assumtions and chose which dimenisions of fidelity to emphasize, how the learner was motivated to engage in active learning and development of knowledge, and how the cognitive changes have been assessed so that there is clear reason to believe the simulation has had an effect on the student's conceptual structures.

Enjoy this issue and we look forward to a repeat in a few years time.

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