# Chapter 9
# Technology-Enhanced Learning Standard through Integration of Modeling and Simulation into Engineering Study Programs

**Dietmar P. F. Moeller**
*University of Hamburg, Germany*

**Hamid Vakilzadian**
*University of Nebraska – Lincoln, USA*

## ABSTRACT

*Introducing a technology-enhanced learning standard in engineering study programs requires a deeper insight into and understanding of the complexity and dynamics of today's engineering systems. This can be achieved by embedding Modeling and Simulation (M&S) within engineering study programs to stimulate educational innovations in undergraduate engineering curricula, such as electrical engineering. An example of this is in the process of being implemented in the Department of Electrical Engineering (EE) at the University of Nebraska – Lincoln (UNL). The need for such programs is evident by recent recommendations from the White House, the U.S. Congress, and the National Science Foundation, all of which stress that M&S is one of the key enabling technologies of the 21st century and is critical to U.S. competitiveness. Various models of a dynamic engineering system can be developed at different levels of detail in accordance with the recommended technical specifications to gain better insight into the behavior, stability, and performance of a system. The functionality of a real engineering system can be tested virtually by changing the structure, parameters, and inputs and outputs of the model to accurately predict the response of the system under various operating conditions. In order to educate a skilled workforce capable of meeting the country's critical needs, the educational requirements for undergraduates in an M&S-based EE program have to be developed. Such a program needs to meet the accreditation requirements set by the Accreditation Board for Engineering and Technology Inc. (ABET).*

DOI: 10.4018/978-1-4666-0951-8.ch009

## INTRODUCTION

Globalization and cooperation in international research and development are changing the way that universities need to educate and train their students. As universities prepare their graduates for the needs of the 21st century and the global market economy, they face significant pressure to overhaul their well-established curriculums. Such an overhaul requires the approval of the faculty and administration. Simulation-Based Engineering Science (SBES) is an emerging area with the potential to provide graduates with the skills they will need to meet the challenges presented by increasingly complex and sophisticated designs as well as pressure to shorten the time to market window.

To ensure that university graduates are prepared to meet the challenges of a global market, the methodology for educating engineering students must be broadened. M&S can provide engineering students with the skills, tools, and training needed to verify and validate the details of complex designs through various design models. The results from these models can be analyzed to ensure the system will be error free and will perform according to the specification and requirements defined.

Recognizing the importance of M&S in science and engineering, the 2006 NSF Blue Ribbon Panel Report (SBES, 2006) states that continued advancement in this field is critical for resolving a multitude of scientific and technological problems facing the United States. In addition, the White House American Competitive Initiative report (ACI, 2006) identifies M&S as a key enabling technology of the 21st century.

Modeling and simulation provides a better understanding of the behavior of a new or existing system by creating various models of the system to observe its behavior at different abstraction levels simply by changing various parameters. In order to study a system using M&S, one needs to develop a purpose and reasons for simulation. Developing such a purpose is valuable, as outlined in the NSF Blue Ribbon Panel Report (SBES, 2006). For example, a simulation study can be performed to test and optimize the design of an engineering system before it is built. This will help to avoid development of several costly prototypes, which is necessary to correct possible errors and ensure that the design is safe to produce. Such assurance is especially important because of the diverse, interdisciplinary nature of today's engineered systems and the demand for advanced system solutions and functionalities. Such demands require embedding M&S in engineering study programs to help students learn to analyze, compare alternatives, make decisions, and implement designs. This is critical to their education because the various models of a system can be manipulated easily by changing various structural parameters or input and/or outputs to accurately predict the correct functionality and performance of the real engineering system.

A derived model achieves its purpose when an optimal match is obtained between the simulation results obtained from the model and the data sets gathered by experimentation and measurements of the real system's parameters. Hence, M&S is an auspicious field, which possesses tremendous potential for facilitating engineering solutions and providing a platform from which to educate students and conduct research on complex matters that would have not been feasible a few years ago.

Teaching M&S in engineering study programs requires the development of suitable models for a variety of engineering systems and/or processes, which necessitates a thorough understanding of the system and its operating constraints. Consequently, an M&S study program in engineering has to cover the methodology of model building as it applies to the understanding and resolving of a multitude of issues, which requires Electrical Engineering (EE) knowledge to develop mathematical models to fulfill real engineering system constraints.

Now that computers and smart phones have become an integral part of the daily lives of