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A MODEL CURRICULUM IN MODELING AND SIMULATION: DO WE NEED IT? CAN WE DO IT?

Roy E. Crosbie

McLeod Institute of Simulation Sciences
California State University
Chico, CA 95929, U.S.A.

ABSTRACT

An international debate on the need for a model curriculum for graduate programs in Modeling and Simulation (M&S) continues to grow. As the use of M&S continues to expand to new application areas, and its importance as a key enabling technology in the 21st century continues to be recognized, many questions are being asked by both universities and corporations concerning the proper basis and content for advanced studies in M&S.

Corporations and government bodies are experiencing rising demands for new recruits with broad exposure to the concepts and methodologies of M&S and capable of contributing to the increasingly important M&S activities within the organization. Many recruiters are, however, frustrated in their efforts to define productive sources in US universities that meet these needs.

1 INTRODUCTION

M&S education was a major topic of discussion in the 1999 WSC from which emerged a number of key questions, such as:

- What are the reasons for shortages of modeling and simulation professionals?
- How should education in M&S be organized so as to attract more students?
- What educational strategies would meet current and anticipated needs in M&S?
- What are the goals of an educational curriculum for simulation?

Many university departments are making efforts to answer these questions, but this is often done within the context of the traditional disciplines that define the scope of activities and interests within most academic departments. Undergraduates in Electronic and Computer Engineering, for example, are usually introduced to simulation tools as part of their electronic design curriculum, but the emphasis tends to be totally on the application with little attention paid to the underlying simulation methodology. Computer Science majors often take at least one course in discrete-event simulation, often involving the use of a discrete simulation language, and in some cases the basic concepts of M&S are also covered, but the focus tends to be relatively narrow and may not address the full scope of M&S applications.

Consequently few graduates, either from Bachelors' or Masters' programs, have adequate exposure to simulation and its relevance as a general problem-solving tool. This raises several questions:

- Should the M&S content of relevant first-degree programs be expanded?
- Should M&S be covered mainly in graduate programs?
- Is there a place for a Masters degree specifically in M&S?
- What should the curriculum be for such a degree?

The McLeod Institute of Simulation Sciences is a network of university-based centers focused on education and research in modeling and simulation. Currently there are 19 centers in North America, Europe and Asia. The questions posed above have been the subject of lively debate in many of these centers for years, and some of the host universities have moved in the direction of offering new programs on M&S. For example, California State University, Chico has for several years offered options in Simulation Science and Computer Simulation as part of its Interdisciplinary Studies graduate program; Old Dominion University now offers both M.S. and Ph.D. programs in Modeling and Simulation; and several of the MISS Centers in the US and Europe are collaborating on an initiative to share M&S-based course offerings over the Internet to provide a virtual campus for M&S studies that will share the expertise in different universities and allow geographically-distributed enrollments in M&S courses.

The time seems to be overdue for the development of a model curriculum for a graduate program in M&S. A model program would need to be flexible, recognizing the broad inter-disciplinary scope of the subject, and the fact that few, if any, universities are in a position to cover all aspects of a broadly-based curriculum. A model curriculum would also provide a structure on which to base multi-campus distributed programs with different campuses covering different aspects of the program. Finally, a major problem with developing new courses in M&S, especially on unifying approaches that bring together different methodologies and applications into a single course, is the dearth of suitable textbooks. The creation of a generally accepted model curriculum would provide an incentive for the creation of new texts written specifically to support it.

The key questions posed in this presentation are:

- Do we need a model curriculum for graduate programs in Modeling and Simulation?
- If a model curriculum is needed, how do we go about creating it?

The presentation will attempt to answer these questions and give suggestions as to the topics that should be included in the model curriculum.

2 THE NEED FOR A MODEL CURRICULUM

The need for more graduate programs in Modeling and Simulation is well established. This has been underlined by the discussions at recent conferences and the increasing number of enquiries from companies seeking to recruit M&S professionals. The question raised here is whether the publication of a model curriculum would help to promote the development of new programs.

I believe that it would, and my reason is based on my experiences in the 1980s as a member of a group of faculty seeking to introduce a new BS program in Computer Engineering at CSU, Chico. At that time, degree programs in Computer Engineering were relatively uncommon in the US, but there was an increasing demand from industry for graduates with a combination of hardware and software skills not normally found in traditional computer science or electronic engineering graduates. One of the factors that gave our efforts credibility, as well as guidance in curriculum design, was a model program published by ACM and the IEEE Computer Society. In the same way, I believe that an effort by the professional societies involved in M&S to create a model program, at least for graduate programs in the field, is long overdue.

One of the problems with establishing a program in M&S is that the field has both an interdisciplinary basis with elements of computer science, engineering and mathematics, as well as an ever-growing scope in its applications. This makes it difficult for any institution to provide a full program in M&S that is sufficiently comprehensive in its scope. This is the reason why several of the MISS centers are currently developing web-based courses with a view to establishing a "virtual campus" for M&S studies, in which students can construct a program to meet their specific needs from the offerings of several universities. There is, however, a danger that this approach will yield a shopping list of courses with no underlying program structure, and that students will simply accumulate sufficient credits to obtain a degree with no guarantee that essential fundamentals have been adequately covered, or that the courses are properly coordinated with each other. This is where a model program would be very helpful.

An important point to note is that a model program is not the same as a set of accreditation requirements. Rather than mandating that certain features must be present if a program is to be accredited, a model program is a set of guidelines that are intended to assist program designers in developing programs. The model program should also be defined in terms of topic lists that recommend both required and optional topics rather than complete courses. The aggregation of topics into individual courses should be the responsibility of the program designer. This is particularly important if the model program is to have international validity bearing in mind the different program structures and course durations that are common in different countries.

3 CREATING A MODEL CURRICULUM

At least three components are essential to the creation of an effective model curriculum that will achieve wide recognition. One is the involvement in the definition of the details of the model curriculum of academics with experience in the field of M&S, second is the support of representatives from industry and public bodies with a need to recruit the graduates of M&S programs, and third is the underpinning of the entire process by representative professional bodies such as ACM, IEEE and SCS.

While the creation of a model curriculum will ultimately involve actions by professional organizations, initial progress will probably depend on the efforts of a self-appointed, dedicated ad-hoc group to produce an initial proposal. One source of members of this group is provided by the MISS centers around the world, another could come from volunteers at M&S-based conferences with an educational component such as this one. I invite anyone who is interested in this effort to contact me at <rcrosbie@csuchico.edu>.

4 ELEMENTS OF THE MODEL CURRICULUM

Consensus on the details of the model curriculum will require considerable discussion between groups with

different perspectives, reflecting the multi-facetted nature of the subject itself. It seems appropriate, however, to identify a few features that might be included, at least as topics for discussion.

4.1 Continuous and Discrete

It has been customary for many years to separate simulation methodologies into two approaches referred to as continuous and discrete. Most courses, and many complete degree programs tend to emphasize one or other of these two approaches to the almost total exclusion of the other. While this is understandable, and indeed necessary, in some of the courses that make up a complete program, the overall program should cover both methodologies in a balanced and integrated way. A fundamental approach to the modeling process and the manner of its implementation on computers requires that students understand the differences between a modeling approach based on continuously advancing time and changes in variables and one that uses event-based discrete advances in time and discontinuous changes in variables. They should also be familiar with the underlying mathematical concepts such as differential equations, queuing theory, discrete math, statistics etc.

4.2 Fundamentals of M&S

The curriculum should also incorporate a general introduction to the basic fundamentals of modeling and simulation. This should cover the modeling approach, classification of conceptual models used in simulation, approaches to implementation of conceptual models on computers, verification and validation, domains of applicability etc. A study of the sources of errors in computer simulations should also be included.

4.3 Simulation Tools and Techniques

All students should have familiarity with the range of software tools available to support and implement computer simulations. This should include familiarity with at least one continuous and one discrete simulation language, as well as the use of analytical tools, spreadsheets etc.

4.4 Applications

A comprehensive program in M&S should provide a range of courses on different application areas. This is necessary if the program is to cater for students from a range of disciplinary backgrounds. Students should be required to include courses from at least one application area in their programs of study.

5 CONCLUSION

There is a strong case for the development of a model curriculum in M&S sponsored by the lead professional societies in the field. A task force made up of interested academics and representatives of industry and government should be established with the goal of developing a draft model program as a basis for further discussion.

AUTHOR BIOGRAPHY

ROY E. CROSBIE is a professor in the Electrical and Computer Engineering Program at the California State University, Chico. He obtained his doctorate from the University of Liverpool, United Kingdom. His specialties include digital systems, computer architecture, microprocessor systems, and simulation. His email address is <crosbie@ecst.csuchico.edu>.