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CONCEPTIONS OF CURRICULUM FOR SIMULATION EDUCATION (PANEL)

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1 INTRODUCTION (Helena Szczerbicka)

In the Winter Simulation Conference 1999 in Phoenix, a series of discussions, conversations, and exchanges on the topic of personnel to meet the current modeling and simulation demands of the civilian application and world military as well led to the idea of giving this discussion a more structured shape in the Winter Simulation Conference 2000. We continue to discuss the complex issue of Simulation Education. A general demand for modeling and simulation professionals can be observed in a large number of enterprises. However computer science graduates are not adequately prepared for employment opportunities involving simulation as a tool in solving problems. Most computer science majors have very limited exposure to simulation. They gain experience in handling of simulation problems by on-the-job-training. Moreover, there doesn't exist any consensus of simulation as a discipline. The following questions hence emerge:

- What are the reasons for shortages of modeling and simulation professionals?
- What would make simulation into a discipline?
- What skills should professionals develop during the education and training?
- Impact of developments in simulation technology: what do we educate simulation professionals for?
- What are educational strategies to meet current and anticipated world needs in simulation?
- What are the goals of an educational curriculum for simulation?
- How to organize education of simulation to make it attractive for students?
- What are criteria on selection of tools for teaching simulation?
- Are there initiatives currently going on in the Modelling and Simulation community to establish some structure in the M&S education and training?

The panel collects 6 simulation professionals from educational institutions that currently offer simulation programs, and non-educational organizations with interests in simulation education. The objective is to address issues related to the growth and need of degree programs in simulation. The panel members from academia, enterprises using simulation software and developers of simulation software provide a solid basis for evaluation of the situation and formulate some recommendations for the future direction of simulation education. In this paper we provide their views in particular on:

- reflections on Modeling and Simulation as a discipline,
- experience of academicians teaching simulation regarding curriculum, especially universities offering a degree in simulation,
- requirements on skills of simulation professionals formulated in application domains, and by simulation software developers, and
- requirements on content of simulation courses coming from engineering and science. Should simulation program be an interdisciplinary education with an independent degree on simulation, or should be a collection of specialized, on-demand assembled courses within an engineering degree?
- should different types of students be reflected in curricula?:

  - Computer science majors with strong knowledge of software engineering
  - Engineering students with strong knowledge in particular technical application domains
  - Business students, with skills in OR but without knowledge on software engineering as well
  - Training programs for managers and engineers.

2 SIMULATION DEGREE PROGRAMS: NEEDS AND CURRICULUM PHILOSOPHY
(Ralph Rogers)

In 1996, Old Dominion University began a broad and sustained effort to expand the role and vision of modeling and simulation for the university. This lead to the creation of the Virginia Modeling Analysis and Simulation Center, followed by the founding in 1998 of a master's program in modeling and simulation and a Ph.D. program in modeling and simulation in 2000. Motivation for establishing these programs and the general philosophy and structure of the programs are discussed.

2.1 Introduction

Modeling and Simulation is ubiquitous in today's leading-edge concepts and applications in entertainment, training, design, planning, engineering, research, education, and decision making. Current realities include virtual environments where soldiers conduct exercises with teams around the world without leaving their home base. New auto assembly line or microchip fabrication facilities would not be built today without extensive simulation of every aspect of the proposed operation. In the development of new aircraft, parts are tested for form, fit, and function in a simulation before they are turned over to manufacturing to build. The simulation gaming industry is larger than the motion picture industry. The military personnel offices are creating job classifications and career paths in modeling and simulation. Public safety organizations train for natural disasters in virtual environments. Impacts of transportation systems on neighborhood quality of life are simulated and results presented at city council meetings and public hearings. Simulation is touching all aspects of human activity and quality of life as we move into the 21st Century

Despite appearing on the critical technologies lists in the 1990s, computer simulation is a technology continuing to struggle with a lock of focus and identify. The rapid advances in computing technology, especially the development of high performance networks, have driven the expectations and capabilities for simulation studies of larger, more complex systems. However, the educational background and technical skills to function as a professsional "simulationist" are no better supported in extant academic programs than for the older forms: continuous and Monte Carlo simulation (see [Rogers 1997]).

2.2 Background

Both a blessing and a curse for simulation is the lack of a circumscribing or inclusive discipline, that is, an academic focus or home. Likewise, melding simulation and high resolution graphics (in some cases, providing a virtual reality environment) enables new applications but can give users false confidence in the correctness or appropriateness of underlying models. Ever expanding hardware capabilities entice the construction of highly complex models. If the system being modeled is complex, or if the model includes stochastic elements, both model creation and the correct interpretation of simulation-produced behaviors can require a nontrivial statistical analysis. The application of continuous simulation in engineering for fluid flow, motion and maneuvering, and similar physical problems relies on solution of difference-differential equations using techniques from advanced approximation theory in numerical analysis. While Monte Carlo simulation finds acceptance in experimental statistics, the necessary knowledge of random number generation, discrete structures and programming languages lie outside that discipline.

The consequence of this necessary, almost overwhelming, diversity is either the staking of limited claims by several academic disciplines (most commonly, computer science, industrial engineering, or management science) or the benign neglect by all. Like "the man without a country," simulation floats almost invisibly in a sea of academic noncommitment. Note that this is the situation from the perspective of potential "claiming" disciplines. As appreciation of the power of simulation has burgeoned, the perspective of "using" disciplines such as medicine, the natural sciences and the social sciences has become even more desperate: *learn only what you need to apply a software tool to render a "solution" to the problem at hand.*

Juxtapose this disciplinary characterization with the clear evidence of societal needs in simulation. The Defense Science Board in 1990 recognized the importance of simulation in reducing the system acquisition costs by focusing the testing required for such decisions [Horowitz 1990]. The military and defense-related industries are becoming more vocal in their expression of need for simulation knowledge and expertise for both training and decision support, while at the same time, other sectors see decision support as the driving need. Training and the delivery of scarce, expensive treatment in remote areas are major motivators in medicine. Further, a rapidly expanding entertainment industry sees simulation supporting virtual reality as their driving technology for the next five years. (Horizons beyond five years are unheard of in this area.).

Not surprisingly, in the last five years, primarily driven by the military and entertainment requirements (fuelled by the developments in computer technology), the simulation industry has experienced explosive growth in the demand for its products and services. These increased product and service requirements have rippled through the simulation industry creating increased demand for new simulation technology, research and, especially, personnel.

2.3 The Simulation Professional

Simulation professionals appear to be clearly different from engineers, scientists, and technical managers whose duties are closely identified with traditional academic disciplines. Further, they are not readily identifiable in the traditional pools of technical and managerial talent. A typical response from simulation industry representatives seeking simulation professional when asked what they are seeking in an individual is, "I want someone like Joe!" Joe, of course, is unique and his path to simulation competence is unlikely to provide a guideline for finding other Joes.

2.4 Simulation Education

Today's simulation professionals are typically a product of the equivalent of a high-tech apprenticeship and on-the-job training. "Simulationists" have typically evolved under the mentoring/apprenticeship of others such as a university researcher or organizational leader, or simply by successfully responding to pressures of competition and opportunity. While the simulationist's education has typically been grounded in traditional science and engineering degrees, their breadth and depth of simulation knowledge has come primarily through direct trial and error empiricism or through a corporate oral tradition of lessons learned.

What is surprising is that with the importance of simulation as a fundamental tool for enterprise operations, as a significant economic segment of the economy, with its dependence on brain-capital, and as an increasingly important tool in knowledge creation and discovery, most simulation exposure in formal education programs has been through adjunctive or elective courses and projects. Few formal programs exists which purport to emphasize simulation or integrate it thoroughly in the philosophy of the curriculum. Simply, the academic infrastructure necessary to educate and prepare the modeling and simulation professionals or even professionals who must use simulation is minimal, at best. The formal academic infrastructure necessary to educate and prepare the teachers and research leaders to staff emerging academic programs and research laboratories does not exist at all.

2.5 Simulation Education at Old Dominion University

Starting in 1996, Old Dominion University began a broad and sustained effort to expand the role and vision of modeling and simulation for the university. This expanded role and vision included the creation of a research center for modeling and simulation and the creation of graduate programs focused on modeling and simulation. The visions started to take form in July of 1997, when Old Dominion opened the Virginia Modeling, Analysis, and Simulation Center (VMASC). This was followed in September of 1998 when Old Dominion University admitted its first class of students to it new multidisciplinary Master's program in modeling and simulation. Efforts have continued with the Fall 2000 semester bringing the establishment of a Ph.D. in Engineering with a concentration in modeling and simulation.

2.5.1 Old Dominion's Simulation Worldview

Old Dominion's approach to simulation education is based on the following worldview: Simulation is an artificial experiential environment. Simulation is not the real thing. Simulation is used as a surrogate for something else. The goal of the experiential environments is to turn abstractions into experiences. Modeling is the process of creating these artificial environments in whatever media is appropriate. We believe these environments can be classified, based on their expected outcomes, into the three broad categories of Training/Education, Discovery, and Entertainment.

Training/Education simulation provides an experience with a known sought after outcome. That is, the attainment or refinement of some known knowledge or skill. The attainment (or lack of attainment) can be evaluated to standards. Discovery simulation is used to provide experience when the outcome is not known but is sought to aid in the creation of new knowledge either for its own sake or aid decision maker in a decision process. Entertainment simulation provides an experience where the outcome is simply entertainment While these three categories are useful, there are not sharp boundaries between the three. There is overlap among all three categories. Simulation environments can be used for all three simultaneously. At Old Dominion, the focus is on environments for training and education and, especially, on environments for discovery. Of particular interest are those instances where outcomes of the simulation environment include both training/education and discovery.

2.5.2 Simulation Program Goals

The goals of Old Dominion's modeling and simulation graduate master's programs are to educate individuals who can: 1.) Communicate and apply a common structure, foundation and philosophy of modeling and simulation to advance simulation science, methodology, and technology; and 2.) Lead in the application of simulation to address research, societal and market needs in multiple disciplinary problem domains. Graduates of the master's program are expected to provide simulation support and expertise as part of multi-disciplinary research and development teams, lead the development of simulation systems, and conduct simulation studies and experiments. In addition, graduates of the Ph.D. program are expected to conduct original and publishable research in modeling and simulation areas and advance the instruction of modeling and simulation at the university level.

The Modeling and Simulation Program is a multi-department program reflecting the interdisciplinary nature and multi-disciplinary breadth of simulation. As such, the program draws heavily on current faculty, course laboratories and other institutional resources such as VMASC.

2.5.3 Simulation Curriculum Philosophy

Both the master's and Ph.D. program consist of three structural elements of course work: 1) Foundation Knowledge, 2.) Simulation Common Core and 3.) Simulation Systems Concentration. The distinguishing feature an emphasizes a structured approach built around a common organizing framework (i.e. Common Core) which reflects the breadth of simulation and the relationship between sub-specialties of simulation. This emphasis on a structured approach is in contrast to simulation's current exposure in academia that emphasizes domain specific problems and market specific products. Additionally, this approach provides the synergistic mechanism to foster exploitation and use of simulation in other domains and disciplines.

The modeling and simulation programs are available for students who have completed bachelors and/or master's degrees in an appropriate field from a regionally accredited institution. Fields of study typically considered appropriate include science and engineering based disciplines characterized by heavy emphasis on analytical models and analysis. Example of fields could include all engineering disciplines, physics, chemistry, psychology (human factors), economics, as well as certain life and earth sciences. The major focus of the Ph.D. degree is the conducting of independent, original research in an area of modeling and simulation. The major focus of the master's program is the preparation for professional who need to apply simulation environments in a domain area.

2.6 Summary

Old Dominion University has recognized the need to create an academic infrastructure for modeling and simulation including research and development centers and academic programs. Old Dominion's approach is broadly based to recognize the multidisciplinary character and diversity of experience required of those who pursue simulation careers. Old Dominion's perspective's emphasizes an ecumenical view of other academic disciplines and the need to be inclusive to expand the useful applications of modeling and simulation as well as the frontiers of modeling and simulation knowledge.

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3 TOWARDS MAKING MODELING AND SIMULATION INTO A DISCIPLINE

(Hessam S. Sarjoughian and Bernard P. Zeigler)

At the present time, there exist a shared belief among modeling & simulation (M&S) stakeholders (government, industry, and educational institutions) to make M&S into a discipline. However, there does not exist a consensus as how to proceed to establish M&S as a discipline. Arguably, a concerted effort is needed to find answers to the "what", "how to", and "why" questions pertaining to the making of the M&S discipline. To further prior efforts, in July 2000, a new track on M&S Education and Training (MSET) spanning three regular and two panel sessions was introduced as part of the Summer Computer Simulation Conference (SCSC). The participants of the Education & Training Track included the organizers and participants of the previous two workshops as well as new constituents across a variety of sectors. A particular purpose for the M&S Education & Training Track was to depict a representative picture of the current status of the education and training in M&S from academic, government, and industry perspectives. In this condensed writing, we provide views presented during the MSETT and the panel sessions. In addition, we suggest a strategic structured approach to the realization of the M&S discipline with the expectation to stir constructive criticism, new thoughts, and active participation of all concerned, interested parties in this promising undertaking.

3.1 A Brief View of M&S Education

In recent years, some members of the international modeling and simulation community have voiced their desire for introducing some structure into the Modeling & Simulation (M&S) arena. One such broad-based effort was conducted in a workshop organized by Ralph Rogers (Rogers 1997; Rogers 2000) with more than forty participants representing industry, government, and academia from several countries. Industry and government, in part, represented customers of M&S professionals while academicians principally represented educators for such professionals. In August 1998, Ruth Silverman (Yurcik and Silverman 2000) organized another workshop focusing on how to teach simulation to undergraduate computer science majors. The workshop participants ranged from newly Ph.D. graduates to authors, educators, and researchers in the M&S arena. The workshop invitee also included simulation software developers and vendors. Both of these workshops focused on M&S education and to some extent on alternative educational programs within a variety of existing disciplines such as computer science, electrical engineering, industrial engineering, management information systems, and systems engineering.

Aside from these workshops, a number of individuals have written on specific topics such as how to train modeling and simulationist professionals, academic curriculum development, and principles for creating M&S educational programs (Fujimoto 2000; Tucker, Fairchild et al. 2000). While such focused efforts can (and should) significantly impact the realization of M&S as a discipline, they are insufficient to establish M&S as a discipline worthy of its own recognition by academia, government, and industry. In contrast to this approach, we advocate a top-down approach while taking into account the contributions made from existing individual programs some of which have opted not to label their programs explicitly. Indeed, it is most important to bring about a realistic vision for the establishment of the M&S discipline supported by all stakeholders who have contributed to its long history and its present and future.

3.2 Making M&S Into a Discipline

Unfortunately, given the existing status of M&S, it is no simple matter to bring consensus on various topics (Rogers 1997). For example, is there a need for the so-called M&S professionals, what would be the criteria for M&S curricula development, and what the role academia, professional society, and industry should be? Perhaps, the chief obstacles in instituting a common vision for M&S is its extensive widespread use in virtually all-existing scientific fields. Unlike more recent areas such as software engineering and robotics, everyone claims and does modeling and simulation of some form to some extent.

During the last several years, individualistic M&S program have been established at several universities (California State University at Chico – McLeod Institute Simulation Sciences, Old Dominion University, Naval Post Graduate School, and the University of Hamburg). While some of these programs are based on the findings of workshops and serious discussions within the M&S community, others appear to have forged ahead in creating specialized areas within programs such as Computer Science. While some of such programs server positively the establishment of M&S discipline, unfortunately others can have negative impact on a unified, concerted effort that is required to overcome numerous challenges that lie ahead. A critical view of existing programs raises a number of issues such as the followings. What should an accredited M&S undergraduate program be like? What are the implications of establishing programs independently of organizations such as ACM, IEEE, and SCSI (Society for Compute Simulation International)? What are the implications of an M&S discipline given the existence of other disciplines such as various engineering and science programs? Does M&S the province of engineering, science, both, or perhaps something principally different?

3.3 A Strategic Approach

The impetus for making the fragmented M&S field into a "discipline" need come from practitioners and users (e.g., government and industry,) tool developers (e.g., commercial entities and academia,) and theorists and methodologists (e.g., academia and research institutions). Since, we believe there is a growing body of constituents to structure M&S education and training, in this short writing we suggest a preliminary comprehensive foundation appropriate for transforming M&S into a discipline. This approach is inspired by underpinnings developed in the making of Software Engineering into a discipline (Software 1999).

A fully recognized professional status is achieved by prescribing to a developmental path identified by G. Ford and N.E. Gibbs (Ford and Gibbs 1996). The ideal professsional (e.g., Electrical Engineer or an architect) is educated by obtaining initial professional education (generally

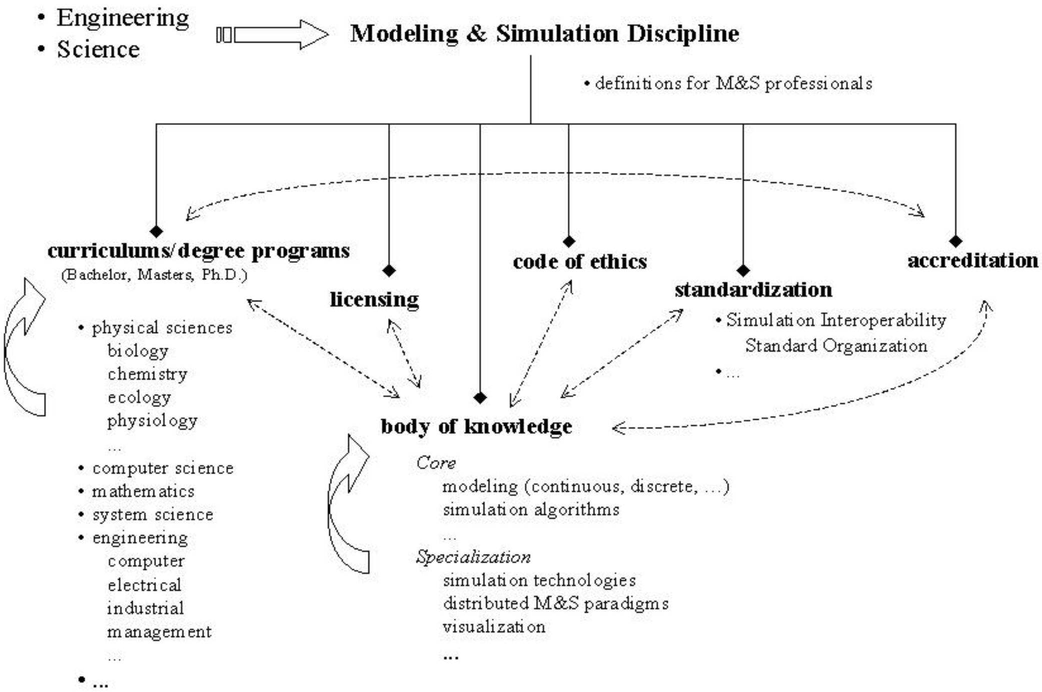

Figure 1: An infrastructure for the Establishment of M&S Discipline

Bachelorette Degree), receiving on-the-job training and experience (skill development), obtaining license or certificate, exercising code of ethics, and continual professsional development.

Within some professions (e.g., M&S,) government and commercial entities (Defense Modeling and Simulation Organization, Aegis Technologies, Cisco, Sun Microsystems, and Rational to name a few) offer short courses and alike to educate student/professionals about their standards, tools, and methodologies. Henceforth, academic institutions, employers (e.g., industry), professional societies (e.g., ACM and IEEE), and commercial entities collectively realize the necessary infrastructure in the creation of M&S professionals.

In Figure 1 above, we sketch an infrastructure for the establishment of M&S discipline. In this short writing, we do not expound on key details of components and their various existing or potential relationships. The relationships exist both vertically and horizontally. For example, a potential debate is on whether the M&S discipline should primarily be based in engineering education principles alone or to include others such as science and liberal arts. Similarly, there exist concrete interdependencies between, for example, curriculum/degree programs and body of knowledge. Detailed exposition of such fundamental relationships will require in-depth discussions are subjects of forthcoming writings. To transform current ad hoc M&S education efforts into a cohesive, disciplined one, not only we need to arrive at a balanced view of our field but also work closely in collaboration with other related disciplines to achieve short and long terms goals of the M&S discipline.

3.4 Panel: Visions For the Future M&S Education and Training

The development and growth of Modeling and Simulation – as a discipline, a profession, and an industry – is strongly bound up with the growth of education and training. Modeling and Simulation has become a technical field that pervades a wide cross-section of science, business and engineering applications and projections for growth in the future indicate an exponentially increasing curve. Unlike some software related tasks, education and training in M&S is essential to enable people to carry out tasks involving M&S with a competence that is not otherwise possible. At this time, the offerings in education and training are not capable of meeting the current and future demand and there must be significant developments in this regard. The panel members brought up some major objectives to further this process:

- Professional modeling and simulationists must be defined and accreditation mechanisms developed.
- University degrees at the undergraduate and graduate levels must be defined and institutionalized.
- Professional development – distinct from university degree programs – must be an essential component of the full education and training package.

To realize each of these objectives will require a lot of effort.

Universities

- need to characterize the discipline of M&S and clearly delineate the discipline from the neighboring ones such as systems engineering and computer science/ engineering,
- must work with other sources of professional training to work out areas in which each should concentrate and combinations of offering that work as a coherent whole, and
- must work with funding agencies to establish programs of research and education needed to advance the field and adequate funding for their implementation.

M&S-based Companies/ Corporations using M&S

- must work with Universities to characterize the current and future types of M&S professionals they will hire and what their educational background should be,
- must coordinate their education and training programs with those of Universities for a coherent set of offerings,
- should collaborate with Universities to establish research teams that can respond to requests for proposals from government funding sources.

(Each company/corporation will have a different response to these imperatives depending on its own situation.)

3.5 Acknowledgments

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4 EDUCATING THE SIMULATIONISTS

(Tuncer Ören)

4.1 Introduction

The question of "education for simulation" can better be analyzed by understanding who are the beneficiaries. It seems to me there are two types of beneficiaries: the (future) simulationists and other professionals who may be benefiting from the use of simulation. Hence in this brief presentation, the following is done: (1) a definition of the term simulationist is given to provide a framework for analysis, (2) the need of the simulationists is outlined to answer the question, and (3) the complementary question, i.e., "simulation for education and training" is analyzed to address the educational need of simulationists who have to be educated to offer the solutions.

4.2 Definitions

Simulation is goal directed experimentation using dynamic models. Hence, it provides repeatable experimentation opportunities under controlled and extreme conditions. It can be used for analysis, design, and control problems. The aims of using simulation are, respectively, gaining insight, performance prediction, and finding appropriate values for input variables for a desired behavior.

Simulation has many facets and depending on the scope of education or training, different abilities should be acquired by future simulationists.

In a recent article on responsibility, ethics, and simulation a broad definition of simulationist was given:

> "A *simulationist* is *somebody* who is involved, full-time or part-time, with at least one of the following activities:
>
> - *Collects and/or specifies data* to be used for/by simulation models. (In analysis problems, by designing experiments, by performing instrumentation, calibration, a.s.o.

In design problems, by providing explicit assumptions, by allowing implicit assumptions, and by formulating and certifying specifications).

- *Develops models* to be used for simulation purposes.
- *Engages in VV&A* (validation, verification, and accreditation) *studies.*
- *Performs simulation studies;* ie. specifies simulation problems, causes generation of model behaviour and performs analysis/interpretation of the generated model behaviour.
- *Formulates* (specific or policy) *solutions* to problems based on simulation.
- *Develops simulation software,* simulation software generators, or simulation tools.
- *Manages* simulation projects (engineering or administrative management).
- *Advertises and/or markets* simulation products and/or services.
- *Maintains* simulation products and/or services.
- *Advises other simulationists.*
- *Promotes simulation-based solutions* to important problems.
- *Advances simulation technology.*
- *Advances simulation methodology and/or theory.*" (Ören 2000).

4.3 Educational Needs of Simulationists

The educational needs of simulationists show a large variety. The scope of activities of simulationists can be broadened. Taking the definition as a framework, one can perceive that different type of simulationists have different educational needs. For some, teaching a simulation software may appear to be sufficient. Some others, may need in-depth knowledge on modelling and simulation methodologies, techniques such as statistics, or knowledge of the application area.

In addition of these educational requirements, simulation as a field should develop a code of ethics that has to be part of the educational requirements of simulationist.

4.4 Simulation for Education and Training

Simulation can be used to support education and training in any area where systems are dynamic and/or dynamic models are involved. A wide spectrum of application areas exists, such as simulation involving queuing networks –as it is the case in most business simulations– and simulation of systems that can be modelled by ordinary or partial differential equations –as it is the case in most engineering or scientific applications.

In defense applications, three types of simulations are distinguished: live simulation, virtual simulation, and constructive simulation. The term "live simulation" reflects the military point of view that "anything other than war is simulation." In a *live simulation*, real people operate real systems and often use laser-simulated guns. A *virtual simulation* is basically use of simulators, such as aircraft or tank simulators for training purposes. A *constructive simulation* is gaming simulation.

Gaming simulations can provide extensive experience with complex systems where decisions of the opponents have to be taken into account. Business games, war games, and emerging conflict management games provide training of decision-makers in the respective areas. Some less known applications of use of simulation include ethical issues.

In summary, at practically every level of education and training there are several opportunities for the applications of simulation for education and training. These applications of simulation can be for the education and training of individuals or groups of people and can work on different types of platforms: PCs, intranet, and on Intranet. Web-based simulation as well as applications of simulation in virtual reality and augmented reality has several professional application areas. Some simulationists, working alone or in groups have to deliver such solutions.

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5 SIMULATION EDUCATION, INDUSTRY VS ACADEMIA (Jerry Banks)

After spending all of one year in industry, I am now qualified to discuss the differences between industry training and academic education in the area of simulation software. I will make this comparison using Table 1.

First, the objective of training for industry and education for academia is different. Persons that come to industry training usually have a pressing need for use of the software. This keeps their interest higher than that of students in a classroom who are learning to use simulation software as part of a required course on simulation.

Next, the industry audience is non-homogeneous. People come to class ranging from those with little or no computing background to those with a thorough computing background. This presents challenges to the instructor.

Table 1: Education for Industry Contrasted with Academia

Consideration	**Industry**	**Academia**
Objective	Provide training for use of products	Support course on statistical aspects of simulation
Audienc	Non-homogeneous	Homogeneous
Preferred teaching method	By example	By example
Categories of students	Managers and engineers	Students only
Pace requested	Go slower	Go slower
Class size	Small	Large
Responsibility for information transfer	Instructor	Student
Evaluation	Little or none	Grades
Assignments	Solve in class	Solve out of class
Frequency	Respond to demand	Function of supply (of teachers)
Length of training	Short (one week)	One academic term
Quality	Must be high	Can vary
Use of training	High % solve real problems	Low % solve real problems

How to keep the audience interested and involved when it is sometimes necessary to run in low gear? The academic group is relatively homogenous, with the same course material as prerequisites.

After many years of teaching simulation in academia, and some experience with industry, it seems that the best way to teach is by example. It is much easier to learn a software application when it is presented in this manner.

Class attendees in industry are usually managers and engineers. The managers attend class to see what their employees need to be doing. Engineers come to a course to achieve sufficient competency with a tool that they can use in practice. In contrast, the attendees in academia are students only with virtually the same background.

In industry, the instructor is responsible for doling out all of the information that is needed. In academia, the student oftentimes has to dig for the necessary information. It may be peculiar to my teaching method, but both groups, industry and academic, say ‘slow down.’ The material that we are teaching is quite familiar to those doing the teaching, but when it comes at such a high transfer rate it becomes overwhelming for the newcomer.

Class size in industry is limited so that each attendee can receive personal attention as required. In academia, class sizes are big in order to reduce the cost of education. In industry, the evaluation of attendees is subjective, based on instructor impressions. In academia, the student is tested or has to submit solved problems to attain a grade.

In industry, the student solves assignments in class, working alone or in a group. In academia, assignments are given and the student is expected to complete these out of class.

The frequency of course offering is a function of demand in industry. In academia, although demand is important, the availability of instructors governs the frequency of course offerings. The length of training for industry is typically one week or less. In academia, the length of the instruction period is one term, or a large fraction of that term. The quality of instruction in industry must be high to alleviate valid complaints from the audience. The quality of instruction in the classroom can vary. Complaints oftentimes fall on deaf ears.

Finally, a high percentage of those taking training in the industry setting are going to use the software (very soon). Otherwise, they would not be spending all of the money to come for a week to training. Undoubtedly, a low percentage of those taking a simulation course in academia will ever use the software. Again, these are some of my observations. Other persons, with varying vantage points, may see things entirely different than me.

AUTHOR BIOGRAPHIES

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