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TEACHING SIMULATION: A PANEL DISCUSSION

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ABSTRACT

This panel looks at the issue of teaching simulation. It brings together three individuals with a wide diversity of academic and industrial experience to discuss the key issues that should be taught in a simulation course. Questions discussed include: Should a simulation language or general modeling concepts be taught in a simulation course? Should there be a difference between simulation courses taught to engineering and business school students? What simulation tools and skills should be taught to satisfy the needs of industry who hire engineering and business school graduates? These and other issues will be discussed.

1 INTRODUCTION

Over the past couple of years, there has been a growing movement to revamp engineering and business school curricula. In several instances, these changes have had a direct impact on courses in OR/MS in general and simulation in particular. The main motivation for this panel was to bring together a group of experienced individuals from academia and industry to discuss simulation education.

The panelists will present their experiences and perspectives on simulation education. In addition, they will also discuss future directions for the development and integration of simulation concepts into engineering and business curricula.

2 DAVID WITHERS

The charge to the panel was, "...what...are important components of a simulation education and what tools should students have when they complete a simulation course?" I would prefer to address an alternate query: What skills should the BS/MS graduate (in a discrete event simulation curriculum) bring to their first industrial assignment in modeling? The following points are from the perspective of a manager of industrial practitioners.

Graduates should bring more than one approach to the analysis of queuing systems: a skill in discrete event simulation as well as an ability to deal with analytic representations. "If the only tool in your toolkit is a hammer, everything looks like a nail" (unknown).

Prospective modelers should possess something between excellent and outstanding written and verbal communications skills. They should be capable of:

- Making formal presentations to peers, customers, and domain experts,
- Preparing technical reports suitable for both executive and technical audiences, and
- Describing an issue or concern in concise, nonpersonal terms.

Since approximately 50 percent of the modeler's time is spent communicating with domain experts, a knowledge of the domain of the system they will be modeling is crucial. They must at least know the vocabulary. A grounding in the sciences and engineering is important, but equally so is an appreciation for literature, art, and business.

Modelers must know how to build a model. See the IDEF0 representation of the modeling process (Withers *et al.* 1993). Critical skills are requirements assimilation, construction of a conceptual model, reviewing one's own or another's model, building and debugging an executable model, holding a code review of one's own or another's model, designing the verification experiment, executing an experiment (keeping track of model versions, run conditions, etc.), analyzing the results—within and across runs, and developing and delivering a cogent report. Note that writing code is only one of many activities.

An enthusiasm/thirst for additional knowledge and an appreciation for continuing education. BS graduates should know about at least one professional society and its publications. MS graduates should know about several relevant societies and their publications. Any graduate should be a member of something. Any graduate should know how to do a literature search—preferably using an electronic database. They should appreciate the advantage of continuing their education.

A facility with at least one tool in each of the following categories:

- High level programming language and an editor
- An operating system for PCs or workstations
- Spreadsheet
- Discrete event simulation language
- Word processor

The selection should be from the most frequently used list in each category. Avoid special tools from academic sources—insist that the premier vendors provide cost effective versions for student/educator use.

3 ENVER YÜCESAN

For an MBA audience, the word "simulation" has two immediate connotations: a spreadsheet exercise and a business game. My role as an instructor is to show that there is at least one more facet of the word "simulation" which represents an extremely flexible analysis tool. In doing so, however, I have to be extremely careful not to project the image that this tool is solely for engineers.

I therefore frame the topic as process analysis. I try to drive home the idea that looking at the process flow provides richer insights about the problem on hand than simply concentrating on a few "frozen" summary figures. This, in turn, may yield a wider portfolio of alternative solutions. Buzzwords such as time competition or business process re-engineering, which tend to take business schools by storm, are also helpful in generating interest and maintaining the enthusiasm.

I then introduce tools for process analysis, starting from very simple ideas. Process flow diagrams (or process maps, as they are gloriously referred to recently) represent a good starting point depicting the key stages of a process in a natural fashion. This is fertile ground for further analysis. One can depict the different people and/or mechanisms responsible for the different stages of the process to identify any imbalances or to discover any holes. One can equally show the "penetration point" of different entities such as "customers" or "manufacturing division" to identify any mismatches. One can also superimpose "processing time" information and conduct a bottleneck analysis, measure the throughput time, identify the inventories.

The next stage is to introduce the "complicating scenarios" such as sources of randomness or interactions with other processes. Queueing models provide a rich portfolio of tools for representing the inherent variability in systems and its consequences. These models also enable a smooth transition to the discussion of discrete-event simulation.

For discrete-event simulation, I have two goals: For the do-it-yourselfers, I aim at providing the basic principles needed to conduct sound experiments, hence, to avoid drawing any wrong conclusions. As for the others, I try to mould them into "educated consumers" of this technique so that, when they hire an engineer to do the job for them, they know the right questions to ask. In other words, they would get their money's worth.

To this end, I follow the following outline in teaching discrete-event simulation:

- Modeling and validation in process analysis
- Languages: strengths, weaknesses, criteria for adoption
- Sources of randomness (coupled with spreadsheet exercises)
- Basic variance reduction techniques (statistical efficiency)
- Output analysis (comparisons, system design)
- Support for decision making (ensuring the continuing validity of models).

4 W. DAVID KELTON

My orders for this panel were to react to the above statements and to summarize. I'll try to do this, but will no doubt fail in avoiding the urge to elbow in a few gratuitous statements myself.

Dave's piece focused on the fact that an analyst needs a toolbox with eclectic contents—encompassing operations-research tools beyond just simulation, but also abilities well beyond O.R., like communication and an appreciation for the arts. This is a good object lesson to those of us in universities in reminding us that we're not the point of the education industry, as much as we might like to pretend that we are. Folks like Dave stand at the end of the pipeline and expect us to produce graduates who can actually do something. And so the question of what a simulation course "ought" to be is secondary, and derives only from the demand for our graduates' skills. Dave reminds us that specialized simulation skills are not the only things he wants to see in a new graduate.

Enver described the kinds of goals and approaches he uses in his classes, particularly with regard to the business-school environment. Key to this is his point that he teaches simulation in a context rather than as an isolated method with its own structure and internal justification. He faces a tough, skeptical audience, and must continually show cause as to why they are hearing about this. And, like Dave, Enver reminds us of breadth—that "simulation" means a lot of very different things and it's essential that he sort these differences out for his students and put the picture in a larger and (for many of his students) more meaningful setting.

Are Dave and Enver in agreement? I think so. While Enver is looking at the "production" process of students that Dave would like to "consume," both (interestingly) wind up stressing the breadth and the interdisciplinary nature of what they are about. Enver needs to place simulation in a broader context of processes and flows, and Dave demands analysts (recently students) who can take simulation as one among many skills that they can apply appropriately and effectively.

It is precisely this broad, interdisciplinary, eclectic nature of simulation that, in my opinion, gives it its strength; this also what drew me to it in the first place since it afforded me the opportunity to combine what I'd learned in mathematics, probability, statistics, computer science, and stochastic processes (I'm not so sure about the arts, but I probably just missed that). Simulation has always been a chameleon, and I suspect will continue to be so as it draws from whatever sources seem appropriate to do the job. This versatility and utter contempt for narrow dogma is reflected in Dave's demand for broad-thinking graduates, as well as in Enver's interesting menu of contexts for the classroom. I want to take Enver's class, then go work for Dave.

I don't believe that there is a "correct" simulation course that can be prescribed, by me or anybody else. While it is obvious that differences in students, curriculum, and potential employers should affect the particulars of a class, I think it is most important that the instructor exploit his or her own particular strengths (and, yes, maybe even biases). I'm interested in computer networks so I do a lot of those kinds of examples in class; I know essentially nothing about military operations and so I avoid such examples. The opposite might be true of somebody else, and the flavor of the class ought to shift accordingly. This is what makes a class interesting (and, yes, maybe even fun) for everybody in the room.

REFERENCE

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