Why NOT Simulation

By Marc Prensky

[3113 words]

Trainers are drawn to buzzwords as bears to honey. Or, perhaps more accurately, as lemmings to the sea, killing their budgets, if not themselves, as they chase after the latest one.

"Simulation," at the start of the 21st century, is a huge training buzzword. (Another is "blended learning" – "I'll take mine on "whip" please" – but I'll leave that for another time.) Of course exactly what "simulation" actually *means* in training is not always clear. One can, like the Gartner Group, define "simulation" extremely broadly, including, in their definition animation, role-playing, if –then process simulation, hands-on practice, what-if interactive models, virtual reality, and games. Of course, this is akin to saying simulation is merely "anything engaging." If that's your definition, Gartner's positioning of simulation as the "killer app" actually may make sense.

But simulation doesn't generally cover all that ground, not at least in the usual sense of the word. Certainly not all learning games are simulations. Role plays are simulations only in the most primitive sense. Simulation, as it is usually defined, involves creating a system (usually, although not always, a computer program) that reacts in way similar to the real world, and thus teaches us about that world in the process.

Used in this sense, simulation, like all buzzwords, has its plusses and minuses. Because it *is* a buzzword, we currently hear lots about its plusses. Among the biggest ones are "learning in safety" (and often at much lower cost than with expensive machinery), and the ability to practice something over and over and experiment with different approaches.

But what about its minuses? We all know how well it works for airplanes, but what about for other, non-mechanical things?

The truth is that despite the obvious success and usefulness of the airplane flight simulator, there are serious problems – many unlikely to be solved in our lifetimes and many possibly unsolvable – with almost ALL simulations, *especially* those that involve simulating people. It is crucial that we realize that the success of the flight simulator does not necessarily transfer well to simulating everything, and particularly – despite many claims to the contrary by creators of various simulations – that it does not transfer particularly well to highly complex, highly indeterminate situations, such as economics, business and human behavior. This does *not* mean that simulation is *useless* in those – or any – cases, but rather that its actual, rather than presumed, usefulness (and cost-effectiveness) in every situation must be carefully considered on a case-by-case basis.

In this article I will give a few of the counter-arguments to simulation. In a useful construct for this discussion, Clark Aldrich of SimuLearn divides a simulation into three parts: Input, Calculations, and Output. Let's discuss the problems with each of these.

INPUT

Other than in highly expensive mechanical mockups, where controls are duplicated down to the last switch (or – better – the actual controls, e.g. cockpit, are used) simulation input is typically not very lifelike. In economic simulations it consists of 'setting" a number of variables – other than Alan Greenspan, few of us actually ever get to do this. While you may sometimes *think* you can just set your own variables such as pricing, in real life there are huge situational constraints. I suppose one could argue that letting someone do something impossible in life (such as set variables anywhere along a spectrum), is a learning experience, but it is certainly an inefficient one.

Second, much input to behavioral-based simulations comes from making choices among given alternatives (e.g. would you do, or answer: A, B or C?). In real life, a limited set of choices is rarely, if ever presented – there are always many more. While there are input systems which purportedly let you type or say anything (by "parsing" natural language) they actually reduce whatever you enter to one of a choice of inputs – that's the only way the machine can function. If they can't make this reduction, you typically get an "I did not understand you, try again" response.

While choosing from a list of options may be an unlifelike way to input in almost all situations except for the most rudimentary, it is particularly unrealistic when dealing with people, or intrapersonal situations – for two reasons. The first is that stated: the variety of people's responses to any situation are always much, much more complex than *any* menu of choices, much less 3 or 4, can indicate.

But another – perhaps more important – reason is that inputting from choices in interpersonal situations leaves too much time for reflection. While reflection is very important in learning, it typically does not happen in the middle of an interpersonal interaction. Face-to-face (or telephone) people-to-people interactions typically take place *without* much reflection in real time. The reflection typically comes later -- I shoulda said… I coulda said... The "reflection" part of a learning simulation generally comes in what the military call the "after action review" or "debriefing." While one could argue that the simulation is teaching you to "think before you speak" (i.e. "depress brain before engaging tongue"), it is not being realistic in its assumption that you can always stop and reflect in a conversation, even if you should. In any *realistic* simulation of interpersonal interaction, you ought to be able to blurt out what you want, when you want, because that's what happens in life.

CALCULATION

The calculations of a simulations' responses, in whatever form they may be programmed, are typically done "behind the scenes," in what are known as "black boxes." The reason for the name is that the user typically has little or no idea of what goes on in there. Creators of simulations would have you believe that these models accurately reflect reality. Unfortunately, the models that these black boxes represent are huge simplifications and approximations, invariably and notoriously incorrect in representing real-world behavior, except in a gross sense (with the exception of purely mechanical objects like airplanes.) And even in those cases, they are only based on data they obtain in actual physical situations and are useless outside of the parameters, such as with highly excessive forces.

Simulation calculations and models have two problems. First, many, if not most situations are hard, – often impossible – to model. A spreadsheet, which allows for "linear" relationships is a good vehicle for modeling financial statements, but not for economic systems behavior. "Systems dynamics" adds the complexity of differential equation-based relationships, which reflect more sophisticated relationships, but not necessarily "real" ones. Other additions, such as independent automata (items that each exhibit limited local behaviors that work together to create complex behaviors), fuzzy logic, and local goal seeking, add more subtlety to the relationships, but also add much more complication to the models making them much harder to manage. Testing whether *any* of these models correlate with actual behavior in all situations is impossible, so it is done very grossly. Outside of machinery, no serious thinker believes we can use models to predict anything but relatively simple system behavior. Think of local weather.

One reason for this is that *all* of the calculation models underlying simulations reflect totally the assumptions and biases of the designer(s), in terms of how they choose, relate and weight the various inputs. For example *Sim City* is well-known for being weighted toward public transportation, an admitted bias of its designer, Will Wright. While some simulation designers try to lay their major assumptions out as variables, allowing the user to change them and see the result, many of the most critical assumptions are typically not in the variables, but in the statements of the relationships between the variables, often formulated as equations. These are rarely if ever open to user change.

Mechanical systems can be modeled well because while they may be complicated, they are essentially simple, not complex systems. Given the exact same conditions, their behavior will always be exactly the same. We call those systems well-determined.

Certain less well-determined dynamic systems, such as military conflicts, can be modeled – albeit much less accurately – based on certain “heuristics” or rules of thumb (a bigger force is likely to destroy a smaller force, surprise counts, etc.) and a set of tables of what happens if x force meets y force.

Business, though, is much harder to simulate than war, because there are many, many more variables involved, and behavior rarely, if ever, repeats – except on a fairly gross level.

And people are the hardest to simulate of all. Human behavior *never* repeats, and is extremely hard to model except on the very gross level of “human nature.” That is why all computer games that model human behavior are very much “cartoons,” i.e. gross abstractions. Many very bright thinkers, such as Jaron Lanier, artificial intelligence researcher and inventor of the data glove, argue that it is folly and arrogant to even try to simulate humans because we will never get there – people are too unpredictable and surprising. Classifying people into, for example one of six (or 20, or 100) character types for purposes of simulation, as many behavioral models do, may be useful for some purposes, but may not buy you very much in terms of achieving “real world” accuracy. Remember, the person who has gone the farthest in simulating people – Will Wright, with *The Sims* – refers to *The Sims* as a "doll house." And even the military simulations involving individual human behavior are so primitive that they seem a toy.

Although mechanical simulations are good for “what-if”-ing in the real world (“Why did the towers collapse?” “How can we design a building that would withstand that type of impact?”) we are much more at sea when it comes to “what-if”-ing non-mechanical systems. Certainly no thoughtful person (certainly not Wright) maintains that simulations can be used for predicting the future, except in the vaguest directional sense. What they *can* be used for is testing the “possibility space” created by the underlying model. But you have to take that model, whatever it is, as only a vague approximation of reality.

Scientist Stephen Wolfram, creator of the software tool *Mathematica* and author of the recently published *A New Kind of Science*, has something to say about why this is true. Our tools of perception and analysis, Wolfram argues, including the human brain, are only capable of analyzing relatively simple – and possibly “nested” – systems. Beyond this, we are in the realm of the “complex” which we have no powers to analyze, other than to watch it unfold. If we try to model it, we are reduced to finding any simple or nested patterns, which may be there, but which don’t really reflect the full, complex behavior of the system. This is true, interestingly enough, even if the complex behavior results from simple rules. It is very hard, if not impossible, Wolfram argues, to go backward and find the rules that underlie complex behavior. Mathematical approximations, such as the formulae used in simulations, don't cut it in these situations.

And even if we actually knew the rules governing human behavior (or any complex system) – which we don't – all we could do would be to "run the program" and see how it progresses, which is what happens in nature. Unless the behavior is simple or nested, we cannot simplify the program with equations.

But what we *can* do, and do do (pun intended) in simulations, is build up artificial worlds with equations. We can then explore the "possibility space" that these worlds provide as they play out. And some of those possibilities might give us some interesting ideas about real life.

It turns out there are some interesting ways to get around the "black box" problem, other than just making some variables adjustable. One of my favorites is the "no black box at all" approach to simulation. In this approach you simulate only the input – e.g. what you might actually observe and find in a situation (say as a consultant). The decisions on how to analyze the information and what it produces is up to you, not the simulation.

OUTPUT

Obtaining really useful learning output from a simulation is not particularly easy. Producing useful output even from mechanical system simulations is hard, because of the many sensorial cues needed to correctly assess a situation. Flight simulators require multidirectional movement and sound in addition to visual output. Fighting simulators require weight recoil and pain on being hit.

Originally, computer simulations provided all of their output in numbers. And many economic and business simulations still do, which is useful to many scientists and to those who are already used to working with financial statements. However the output of simulations was greatly enhanced by translating those numbers into graphs, which can represent changes over time, or positions, such as in chess. Many strategic battle management simulators are still in this stage, using x's, o's and other symbols, as abstractions of a real battle.

An even more useful step, in many cases, is adding less abstract, more "realistic" visuals. So, for example, the volume of traffic in *Sim City* is translated into an animation of cars on the road. Growth is indicated by the size or number of visual objects. A "hit" (really a calculation) is shown by something blowing up. The whole simulation becomes a more sensorial one, with the calculations translated not only into visuals, but also movements and other tactile or haptic information, auditory signals, aromas (this is currently available). Soon, I predict, there will be special food to eat or gum to chew while playing.

Clearly, in most cases, multi-sensory output is preferable to single sensory. Continuous output, of as many variables as possible, is also preferable to output only at the end, because it allows mid-course corrections.

However, it is important to bear in mind no simulation output will be "real life" but it will be rather only those variables that the designer can, and chooses to, present. Decisions which a simulation designer must make include How much do I show? What should be shown in numbers versus in other representations? Do I want varying levels of output (and input, for that matter)? Should they be user choosable? Under what conditions?

And when we are attempting to simulate people and human behavior, the output problem is infinitely compounded. Our choices are basically statements (i.e. written choices or audio only), photographed people (i.e. video) or artificial people (i.e. animations.) While video in some senses "looks" lifelike in that it is pictures of life, neither scripting nor acting of the particular behaviors needed are easy, as any watcher of movies or television can attest. And while animations are getting more life-like, and becoming capable of more expression, they are still basically abstract and "cartoony."

We can accept abstraction in simulated characters, and, according to Scott McCloud, author of *Understanding Comics*, abstraction many even help us to identify better with the characters. But whether you personally prefer the acting of video or the abstraction of animation, the biggest problem in simulations of human behavior is assembling enough of a range of behaviors so the simulation can be varied and non-repetitive enough so that we take it for something realistic and useful.

In video, you have to shoot every nuance separately – once it's on film, you can't easily change it (although this capability many evolve). And although you can change animation without assembling the whole crew and reshooting (a problem over time – think of the Star Trek movies, or James Bond), we still basically construct a model for each emotion and scene (e.g. "character 1 angry, pounding his fist"). The typical approach is to create as small units as possible, stringing them together according to what the simulation numbers tell us comes next.

But people, unfortunately or fortunately, are never just one thing at a time. What about angry and scared? Angry and cunning? Angry and still thinking of all your relationships to all the people in the room? Angry and not feeling well? Angry and worried about your promotion, or your sick family? And of course it gets more complex as all of these combine. We have no way of showing this complexity on the fly – that's why most simulation games involve either cartoon-like characters, simple pre-determined situations or mythical beings who don't behave exactly as humans.

Implications

So what does this all mean for simulation and training? As trainers, it means we need to take all simulations of business, and especially of business people, with a very large grain of salt. Simulations of processes that are non-mechanical may be good for learning some things, on a very gross level, but their underlying models are particularly open to question and involve a large degree of simplification and bias. For training they may possibly be not that much better than "what would you do in this situation" choices verbally or on paper, but for a lot more cost. Trainers typically go for them, as they are cute, a la mode, and seem to be "advanced." But the chances of a user ever finding him or herself in the *exact* situation simulated (even if you simulate millions) is so remote as to be highly unlikely, and the nuances missed may make all the difference. Finally, much, if not most of the learning comes in the discussions after the simulation (the debrief, or "after action review.") In many cases discussion of a written case which everyone has shared may make the same points equally well.

So when *might* we consider simulation as a good tool, and probably (or possibly) worth the money? I would suggest the following:

- For closed, mechanical systems (such as airplanes, and to a lesser extent plants and factories), simulation is a very, very useful tool. However, as they found out with the Airbus that lost the tail, it is only good within the parameters that can be observed and tested.

- For complex open systems, such as economics, business, and *especially* people, simulation is:

    - a pretty good tool for introducing beginners to a dynamic system's gross behaviors (assuming it is cost justified compared to other methods)

    - one of many ways to provide relatively simple affective feedback (depending on the design)

    - one of many ways to explore options and/or discuss the validity of underlying assumptions

    - a good basis for comparing users' approaches in an After Action Review

    - a gross directional tool for prediction (in some cases).

So when it comes to simulation let's, as trainers, avoid being this year's lemmings by using simulation judiciously, only when appropriate and cost-justified. Don't worry, if you delight in jumping off the buzzword cliff you can be sure that next year there'll be another one ☺ .

Marc Prensky is an internationally acclaimed thought leader, speaker, writer, consultant, and game designer in the critical areas of education and learning. He is the author of Digital Game-Based Learning (McGraw-Hill, 2001), founder and CEO of Games2train, a game-based learning company, and founder of The Digital Multiplier, an organization dedicated to eliminating the digital divide in learning worldwide. He is also the creator of the sites <www.SocialImpactGames.com>, <www.DoDGameCommunity.com> and <www.GamesParentsTeachers.com> . Marc holds an MBA from Harvard and a Masters in Teaching from Yale. More of his writings can be found at <www.marcprensky.com/writing/default.asp>. Contact Marc at marc@games2train.com.