I Can't Believe It's a System Dynamics Model!

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Abstract

The system dynamics community has been active in developing model-supported cases studies, gaming simulations and management flight simulators for use in learning laboratories and student workshops. As multimedia environments are being introduced, system dynamics based learning tools are beginning to look increasingly like many commercially developed games.

Developments within the commercial video game markets, including new mass storage media (CD-I, CD-ROM) and multimedia technologies have resulted in a host of new business and policy-related games and simulations becoming available. In this paper, we examine the possibilities for using commercially available games in a system dynamics context. We demonstrate those opportunities through an example, SimCity, a well-known commercial strategy game.

How can the system dynamics community contribute to these new exciting developments in the area of commercial edutainment products? How can we make use of the current interest in strategy games to get more people introduced to system dynamics?

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System Dynamicists who are researching and developing the use of games and simulations as learning tools are finding themselves in interesting, but confusing times. Strategy games are rapidly gaining popularity in the commercial video games market. These games might not, at first glance, have much in common with system dynamics games: they don't follow emerging system dynamics guidelines for the design of effective learning environments, there are no clear learning objectives and most importantly they do not emphasise a structure-behaviour connection. Are *learning* and *entertainment* mutually exclusive activities?

Amidst new year festivities, there was a review in the London Times (31 December 1993) of one of the latest Maxis games *SimFarm*:

> *....so I'm finding it difficult to explain why I am enjoying SimFarm so much, for this latest simulation from Maxis has none of the characteristics currently in vogue with games designers. SimFarm is a gentle simulation where the most important decisions are, shall I plant tomatoes tomorrow or take a chance on some lettuce? It sounds deadly dull, but it is one of the most absorbing games that I have played for months - a strategy game where the only thing that gets killed is the pesky greenfly.*

Edutainment

There is currently much hype about the emerging digital industries - discussions about *Convergence, Multimedia, the Information Superhighway, Communicopia,* and now *Edutainment* are frequent entries in the daily columns. Even the Financial Times (8 March 1994) in an article on the Superhighway described recent "efforts to turn couch potatoes into couch commandos"! Without a doubt, there is a proliferation of new products in the video games industry. Video games are the fastest growing consumer durable product ever - in only three years the market has grown 3000%, to a forecast retail revenue market of £700m this year. There are currently over 700 "edutainment" titles on the market now, with a further 250 coming annually (Business Week, 1994).

The proliferation of products designed to connect to information super-highways means that opportunities for technology-based learning have never been greater. There is, of course, much scepticism for the efficacy of the latest multimedia technologies, just as there have always been (quite valid) doubts on computer-based delivery in the classroom (Verity, 1994). Becoming engrossed in the latest edutainment module won't necessary add any value to the students' learning. Even though games might have an educational component most emphasis is normally placed on the entertainment side. This might be appropriate for young children but produces a problem when the games are used by teenagers and university students as a learning tool. There is a widespread belief in the system dynamics community that learning only take place when games and simulations are used in workshops that are appropriately designed. Most importantly, we believe that learning about systemic structures and their effect on system behaviour is the critical objective in gaming. Most of these commercial games do not attempt to get the player to appreciate the relationship between structure and behaviour, or even reveal information about their structure.

Strategy Games

A new generation of commercial "strategy" games are attracting positive reviews, as the customers (mainly aged 13-19) are switching from "shoot-em-up" and "fantasy" games. There is no doubt that the video games industry follows fashionable trends - and the growing interest in games like *SimCity, SimFarm, SimLife, SimHealth, SimAnt,* and *Civilization* may well be just a short-term fad. But it is an important signal from the market place, which should not be ignored. These games are selling well, but

they do not incorporate the structured learning environments necessary to create an interesting and effective learning experience. Previous work within the system dynamics community (Bakken et al, 1992, Graham et al, 1992, Paich and Sterman, 1993, Langley, 1993) has shown that the game alone is not an appropriate learning tool - and one needs a structured learning environment in which to embed the game. This may include online briefing notes, reference material, pop-up advice screens and debriefing sessions built into the game (Langley and Larsen, 1994).

The briefing material for SimCity users comprises an interesting chapter called "History of Cities and City Planning", a chapter called "Inside SimCity - How the Simulator Works and Strategies for Using It", and a "City Dynamics Chart" showing the direction of relationships between the main variables in the model. This might help the careful player to get some 'primitive' structural understanding but the player will not get a feedback view on the model with closed loops that reveal the long term consequences. Online assistance is not available, nor is any cognitive feedback.

Civilisation, however, a best-selling strategy game for the Mac, is described as "intellectually challenging, engrossing, educational - the online reference files constitute an encyclopedia of human intellectual achievement - above all it's incredibly addictive" (Levy, 1994). Students learn when they are interested, excited and motivated. Any learning experience that generates such interest is likely to be successful. Langley (1993) found some differences in groups that played the Management Flight Simulator, in terms of self-perception of learning achieved and performance in objective tests. "Not surprising" said some colleagues at last year's SD conference - they've spent longer working on the case than students who don't play the simulator! Can we design self-contained simulators which can be run in an open learning environment - which students can then be encouraged to use in their own time? Classroom sessions can be reserved for debriefings involving feedback and discussion.

Using Commercial Games in a System Dynamics Context

Recent studies (Randel et al, 1992, Keys and Wolfe, 1990) report that there is little evidence for the efficacy of traditional business games compared to conventional learning experiences - lectures and case studies. Even some of the latest "best-selling" business games are little more than electronic books (eg. The Strategy Game, Hickman, 1993). To what extent is our work approaching games and simulations differently? We believe that it *is* different, and that some of the problems with traditional business games might be overcome by focusing more on the workshop surrounding the game and trying to isolate specific learning objectives for the gaming session. However this still leaves us with the problem of what to do with the structure-behaviour understanding in traditional business games?

If we believe that the most important thing is to get people to understand that structure is the driving force for behaviour, then we need somehow to get people to appreciate the underlying structure. This is done by system dynamicists using Microworlds such as People Express (Sterman, 1988) or the Oil Producers (Morecroft and van der Heijden, 1992) and introducing the notion of structure in two ways. First, by graphs and causal loop diagrams in the user manual where the model is described. Second, through the workshop in which the game is embedded, the structure-behaviour connection is reinforced. This might be done by using further causal loop diagrams, if possible elicited from the participants in the exercise. Alternatively, through discussions of why a certain result occurred, eg. trying to understand the idea of balancing growth in people, capacity and passengers in the People Express case. However, as System Dynamics Microworlds get more widely used there is a real danger that this message will be lost, as a number of non-system dynamics educated faculty start to use these games. This will be one of the major challenges for system dynamics in the coming years, how can we keep a clear system dynamics element in these games when non-system dynamics people are teaching them?

There is potentially a number of "physical limitations" for system dynamics and gaming. For example, there is a clear capacity constraint on how many games the SD community can, or will, produce. There is also a problem with access to the most appealing interfaces (and the time it takes to construct them). There is an important issue relating to the use of multimedia interfaces - what value is added through

their use? All this raises another interesting question, can we actual use commercial strategy games to convey the message that we normally associate with SD games? We will see in this section how this could be done by using SimCity.

SimCity

SimCity is a commercial computer game which has a large following. As the Mayor of a city (SimCity) you have to make your city grow by designating residential, commercial and industrial areas as the main building blocks under your control. As people (Sims) start to move in they will demand roads, rail-links and power stations. As the city grows you will need to build police and fire stations, football stadiums and parks to keep your city attractive (as you will want to attract as many people as possible). Your commercial and industrial areas will require harbours, airports, roads etc. to be able to keep expanding. On the other hand, commercial and industrial areas generate pollution which has a negative effect on your city's attractiveness. More importantly you will need to finance all this through tax revenue and Sims do not like taxes. If you mess up (eg. do not solve the problems of traffic congestion, high crime rates or excessive pollution) the Sims might actually revolt against you!

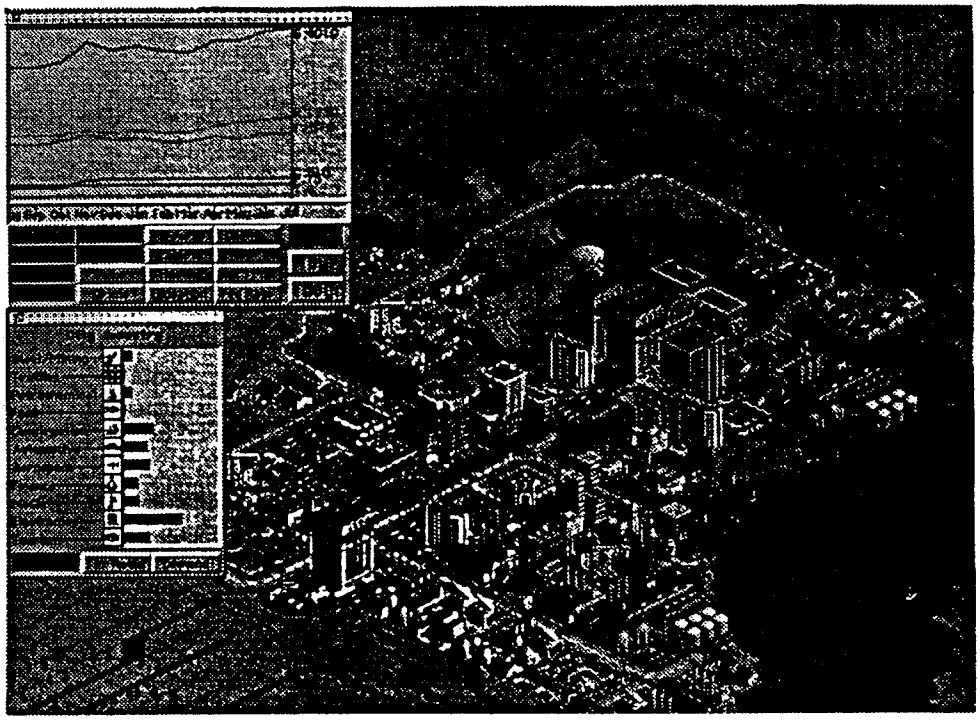

Figure 1. Sim2000 screen display showing the growing city overlooking water, with charts of historical costs and relative size of industries.

The popularity of this game can be judged by the fact that there are published books describing different strategies in SimCity (eg. Wilson, 1990). The game runs on both Apple Mac and PC/Windows platforms. The latest version, Sim2000, has breathtaking 3-d graphics (Figure 1), and the CD-ROM multimedia version is currently in production and due for release in the 3rd quarter 1994.

As time passes the areas that have been designated as residential, commercial and industrial fill up with buildings, hospitals, and churches. You can see traffic on the roads, and trains on the railways etc. You can choose to see the whole city or focus on parts of it. You can get maps which show you the most polluted areas, the distribution of crime, the use of energy etc. From time to time different disasters will hit your town - fires, earthquakes, and tornadoes (there is even a monster - which shows that there is a connection with the more traditional 'space invader' games). The program provides some hints along the way, it might tell you that there is a brown out (ie. that you are short of electricity - brown out is the stage before black out!), traffic congestion or rising crime in some areas.

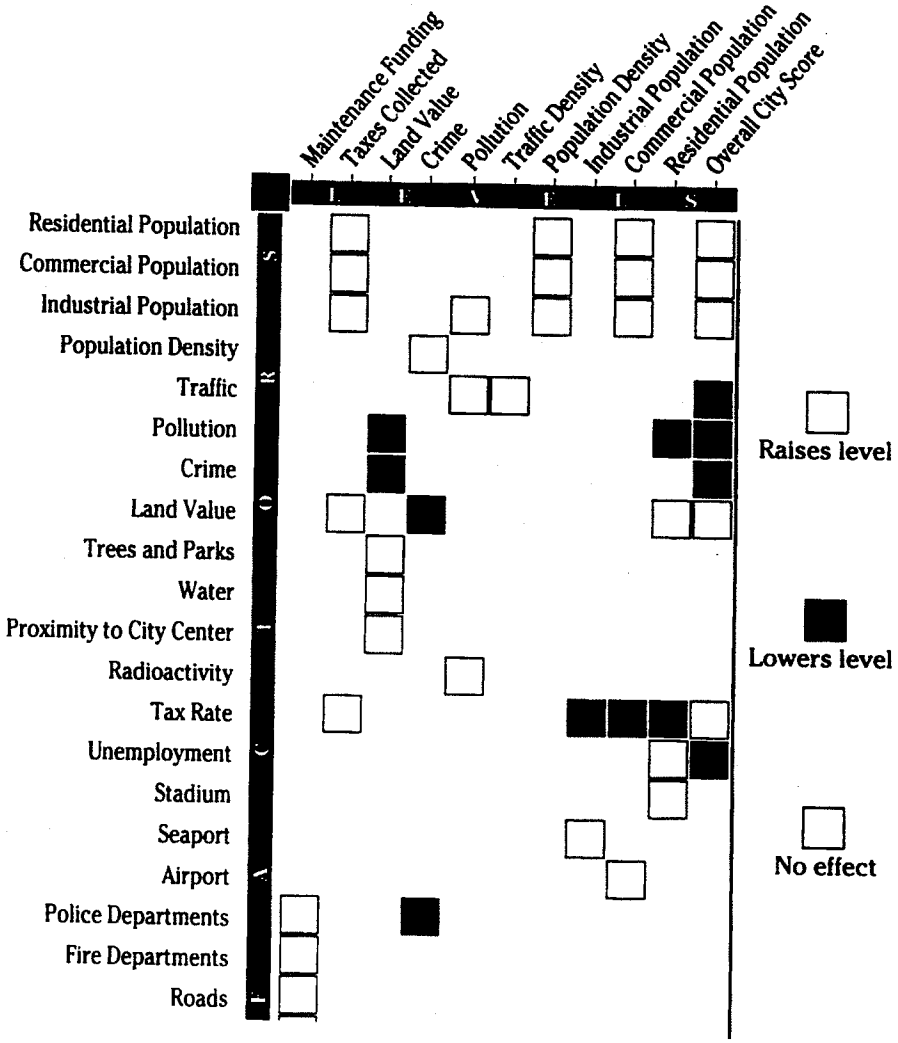

Figure 2. "City Dynamics" Chart for SimCity

Looking at the manual for SimCity there is not much that resembles what we see in System Dynamics. However, there are a few indications that this might be more than just another video game. There is a 20 page "non-fiction" essay on city planning in the manual, with references to books on urban planning. There is a chapter called "Inside SimCity - how the simulator works and strategies for using it". There is also a card (Figure 2) showing some of the factors that influence growth in the city.

By taking these factors we can construct a causal loop diagram which might at least in part give a structural understanding of what is going on in the game. Figure 3a and b shows two of these diagrams. There is of course no guarantee that this is the whole story, and trying to draw up a causal loop diagram will always be a point of concern when it is not possible to examine the actual model. But based on the 'city dynamics' chart, and reinforced by experience, this seems to be a reasonably good representation. You might always have problems explaining a particular event which does not seem to fit into your diagram and commonsense, but there seems to be few of these in SimCity - since Simcity has been around for 5 years and most of the bugs are eliminated.

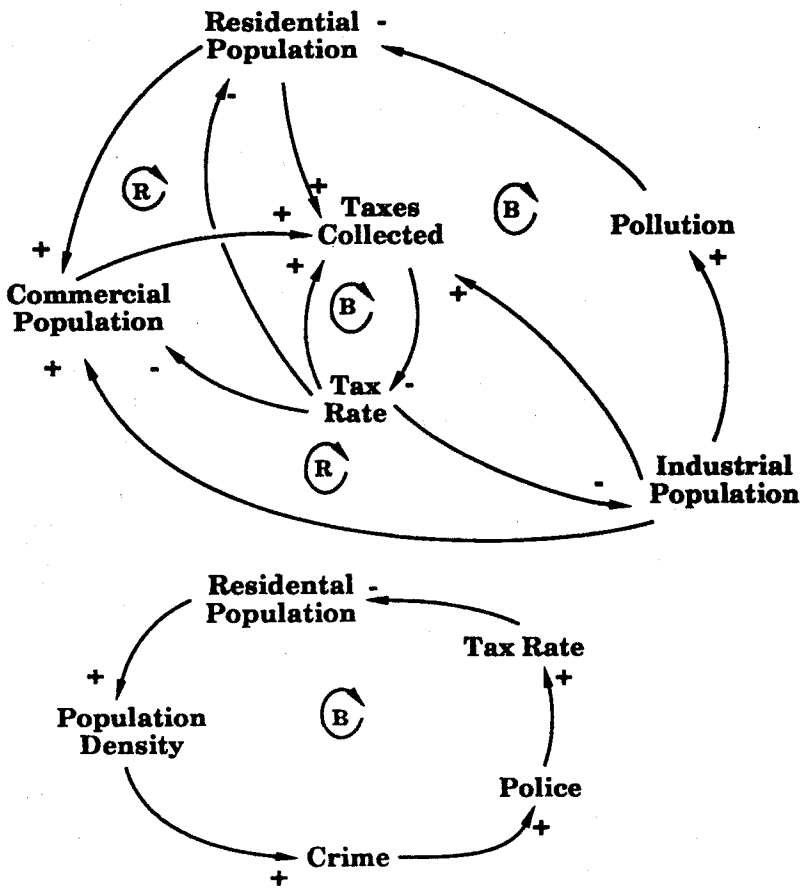

Figure 3a and b. Part of the causal loop diagram for SimCity

The game raises the question of how you manage a balanced growth for your city. You have to make th city attractive for residence, by providing jobs, shopping, and leisure activities such as a stadium, gree parks etc. You must prevent crime, and provide the necessary infrastructure - balancing industrial are (and thereby jobs) against the increasing pollution etc. Figure 3a shows several balancing an reinforcing feedback loops which control the development of the city (please note that not all loops ar identified in figure 3). To be able to expand the city, it's then clear that one has to keep the balanc

between all these loops, in order to get them to grow together. Figure 3b shows another set of feedback loops which will stop the expansion of the city, if they are not handled carefully.

One could imagine that a game like this was used as an introduction to some of the issues raised in Urban Dynamics (Forrester, 1969), which is dealing with many of the same issues. SimCity could be used as a motivation for students, say in high school, to look at how to map the dynamics of an urban city. A lecture based on Urban dynamics could be used to introduce the "straight-forward" issues which are seen in SimCity. After starting with simple causal loop diagrams, and building small models to understand the behaviour created by these structures, students then gradually move onto less obvious issues examined in Urban Dynamics.

Gaming HCI and Models

There is much to learn about the design of the interface from the commercial games. The latest development software (for Windows and the Apple Mac) is becoming increasingly easier to use, and the scope of multimedia interfaces available widens. The first business microworlds made use of Microworld Creator/Explorer to quickly produce a gaming interface (from imported iTHINK or STELLA equations) that worked correctly, and conformed to Apple Mac design standards. Decision windows allowed periodic numerical decisions to be made, and outcome feedback was available in the form of reports, graphs and tables. Six years on, new end-user development tools are available to provide more flexible design interfaces, at low cost. For example, we have made use of Visual Basic for Windows to develop a PC version of the Oil Producers Microworld (Morecroft, 1992). The interface includes vivid photorealistic images (Figure 4), as well as the usual reports, graphs, charts and tables. Cognitive feedback can be included, related to structural understanding - causal loop diagrams, pop-up advice windows, and explanations of outcome feedback. The end product is an .EXE file which can be distributed to users without the need for special gaming software, and which can be run on any Windows workstation.

Discussion

The world in which children now grow up is an electronic world. They seem to be more comfortable with television and computers than with books. If the system dynamics community want to take advantage of this, we need a way of capturing incoming student interest. Recently, there has been a tremendous growth in the edutainment area, which at the current time is growing at more than 250 new programs a year (Business Week, 1994) many of which are for children and teenagers. There is a movement away from "shoot 'em up" towards more "strategic games" (you can only shoot so many monsters!). Even the traditional games for children seem to begin to incorporate an educational component. The child needs to make some algebraic calculations or spell a word correctly before it can move on to the next level in the game (eg. *Mickey's ABCs*, *Millie's Math House*). The games for teenagers (and adults) seem to be evolving in a direction where system dynamics might be able to contribute to the development by providing a learning component similar to the 'spell the word correct before you can move on' element in the children's game.

Paich, M. and J.D. Sterman. 1993. Boom, Bust and Failures to Learn in Experimental Markets. *Management Science*, 39 (12), 1439-1458.

Randel, J.M., B. A. Morris, C.D. Wetzel, B.V. Whitehill. 1992. The Effectiveness of Games for Educational Purposes: A Review of Recent Research, *Simulation & Gaming*, 23, 3, 261-276.

Sterman, J.D. 1988. *People Express Management Flight Simulator.* Software and documentation available from J. Sterman E52, Sloan School of Management, MIT, Cambridge, MA

Verity, J.W. 1994. The Next Step: Reengineer the Classroom, *Business Week*, 28 February, 49.

Wilson, L. 1990. *The SimCity Planning Commission Handbook.* McGraw Hill, New York, NY