Assessing the Efficacy of Microworlds for Promoting Systems Thinking

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Abstract

Constructing a system dynamics model and analyzing its behavior is a well documented practice for enriching the builder's mental model. When there is a larger audience for the use of a model — for example, to help transfer the builder's discoveries — modelers can construct an interface that allows a user to change parameters in a model. Depending on the interface design, these *microworlds* (or *management flight simulators*) may be useful to introduce a larger audience to some of the concepts of system dynamics and systems thinking. Our work examines the use of such microworlds to boost system dynamics skills in the classroom and strategic thinking in commercial settings. The users report that microworlds are useful tools for helping them to grasp and master the intended concepts.

Introduction

System dynamics models have established their place in the formulation of strategy. (Thompson and Weiner, 1996) But the value of microworlds as a tool for attaining deep levels of learning is the subject of much debate. (Langley, 1993) There is considerable discord among researchers concerning the practical efficacy of microworlds in knowledge transfer. (Bakken *et al*, 1992) These concerns must be addressed for microworlds to achieve their promise. However, our work focuses more narrowly: (1) Is a generic microworld valuable for introducing system dynamics concepts in a university classroom? and (2) Are microworlds valuable for stimulating strategic thinking with a system-wide perspective in a commercial setting?

Research, Methods, and Results

In both the classroom and the commercial ("boardroom") setting, we have some common goals. We used microworlds to

- Provide a logical and reasonable view of a system and the interaction of its parts
- Reach and inform a group larger than the model development team about observations and opinions of the model developers
- Calibrate, confirm and socialize the critical thinking skills of a group larger than the model development team

For the boardroom, we wished to create an environment for developing strategy by generating simulation-based experiences that parallel real world experiences.

Our observations come from microworld use by four groups of Cavaleri's graduate and undergraduate business students (about 65 students over two years) and Thompson's group of 24 managers at a Fortune 500 company. The students employed commercially available microworlds. The managers employed a custom microworld from a system dynamics model that simulates disease propagation, market development, drug development and production, U.S. federal approvals process and marketing strategy for a pharmaceuticals company. As such our observations are somewhat informal and rely on anecdotes.

Of the student groups, three had no significant prior exposure to the notion of systems thinking or the discipline of system dynamics. One group, Group I in the data below, had a introduction to some systems thinking (i.e., feedback, causal loops and system archetypes) in about ten hours of classroom lecture and discourse. Aaron™ was used by Groups I-III, and Group IV employed the Service Quality microworld.[1] The students responded anonymously in writing within a week of

completing their experience with the microworlds to eight questions. The questions and response data are summarized below:

Question	Mean Response by Group I (12)	II (21)	III (18)	IV (12)
1. Microworld's overall value as a learning tool in comparison to all other approaches you have used (1 = Not Useful; 10 = Very Useful)	7.91	6.43	7.80	7.66
2. Effectiveness of microworld in helping to develop insight about new ways to manage (1 = Not Effective; 10 = Very Effective)	7.75	6.71	8.15	7.25
3. Effectiveness of microworld in helping to better understand the process of managing (1 = Not Effective; 10 = Very Effective)	7.33	6.61	7.36	7.41
4. Does the learner consider the microworld to be user-friendly (1 = Unfriendly; 10 = Very Friendly)	6.75	5.14	5.68	8.50
5. Efficiency of the microworld in helping to develop insights as compared to other methods you have used (1 = Very inefficient; 10 = Very Efficient)	7.58	5.33	6.79	7.30
6. Has the learner ever used a microworld before (Yes; No)	100% yes	n.a.	n.a.	42% yes
7. Value of the microworld as a learning tool compared to other computer simulations used (1 = Much less useful; 10 = Much more useful)	6.41	n.a.	n.a.	7.11
8. Have your beliefs about managing changed as a result of using this micro world; if so approximately by how much (expressed in a range from 0 to 1)	.41	n.a.	n.a.	.68

The data from the surveys indicate that Cavaleri's learners found the microworlds to be a useful and effective tool for deepening their understanding of managing. By observation Cavaleri notes that advanced undergraduates and graduate students were better able to take advantage of Aaron's sophisticated capabilities while novices found the ease-of-use of the Service Quality microworld to be helpful.

Since the primary focus of the manager workshop was to develop strategy, it was important to keep the pace lively. So, Thompson's users were guided through some of the mechanical processes of manipulating the interface.

Our Observations On The Use Of Microworlds

The above data apply to the use of microworlds in the classroom. But the overarching goals for the classroom and the boardroom use of microworlds go beyond ease-of-use questions. Specifically, we use microworlds to steepen the learning curve — to shorten the time from introducing to grasping a topic with rich dynamic complexity. Our approach to these goals is similar in the classroom and the boardroom. Here, the boardroom is a workshop centered on the microworld.

The common steps we follow are —

- Familiarize participants with *apriori* of system dynamics
- Introduce participants to the concepts of feedback and reinforcing and controlling feedback loops
- Review the structure of the simulation model that underlies the microworld
  - Review the issues addressed in the simulation model
  - Provide a high-level view of the major feedback loops
  - Review model boundaries through discussion of inputs and outputs from simulation
- Analyze simulation outcomes and explore choices for policy changes to improve system performance

In the classroom, these program steps are usually accomplished with Problem Sets. In the boardroom, the same program steps are taken with a Scenario Generation and Evaluation Workshop. Emphasis is placed on observing performance of important variables in various simulation settings. Students and managers learn to trace the causes of systemic performance to the structure of the system.

Both microworlds employ an interface that allows access to a graphical representation of the system dynamics model. In the student's microworlds, this portion of interface was a causal loop diagram. For the manager group, the interface accessed a complete stock and flow diagram. For both, the users could access all model equations and trace causes of simulation performance through the application environment. We believe that all user groups benefited from using these tools. In particular, the explicit representation of the interconnectedness of variables helped users to relate model behavior to their experience in the real world. This validation-by-use may place an extra burden on the model's creators, but it is an important test that enables users to gain confidence in what they are seeing.

The problem sets required the students to repeatedly use the same model with variations in parameter settings for simulations run over a period of weeks. The manager workshop required the participants to run simulations with different parameter settings over the course of about eight hours.

The completeness of model sectors allowed the users access to data that they may not be likely to consider in other environments. We take this as both a microworld weakness and a strength — a weakness because the users sometimes experienced information overload and a strength because the users found that previously held notions of cause-and-effect were challenged by the structure of the model. The users often found important and subtle policy levers by thoroughly tracing causes for simulation performance.

Here are some comments from our follow-up interviews with the managers —

- This confirms the importance of improving our analytical skills to shorten the time to high quality decision-making. In today's intensely competitive environment, we can no longer afford the time to ponder endlessly and avoid making the tough decisions. We need to think crisply and be wise stewards of our time. *CEO*
- I liked the part where we ran the scenario and then talked about the real world. The computer [microworld] deflected a lot of the negative thinking. Market analyst
- The group surprised me. I expected everyone to duck when they realized [our product offering] might not be a world-beater. *Research physician*
- The frightening thing for middle managers is that people with a few years' experience can learn all their tricks in a day or two. You better watch out – by enabling the inexperienced, you threaten the proprietary knowledge of middle management. *Industry senior consultant*

Summary

Inexperienced users gained, or increased their appreciation of, critical thinking skills. Our microworlds' dynamic complexity, lively behavior and believable outputs encouraged users to relate simulation experience to their observations of the real world, and so to socialize the concepts captured in the model among a group larger than the model developers. We are reluctant to draw more conclusions from such a small amount of data. But we are encouraged by the results so far. The microworlds have helped the users to quickly develop a system-wide view and enhance their knowledge of interconnectedness between parts in that system.

References:

Bakken, B., J. Gould and D. Kim. (1993) "Experimentation in Learning Organizations: A Management Flight Simulator Approach" in *Modeling for Learning Organizations*, John D.W. Morecroft and John D. Sterman, editors. Portland, OR: Productivity Press

Langley, Paul A. (1993), "Learning with Model-Supported Case Studies" in *Proceedings of the International System Dynamics Conference 1993*, pp. 245-254. Cambridge: The System Dynamics Society

Thompson, James P. and Joan Weiner. (1996) "Strategic Planning As A Tool For Building Learning Capacity" in *Managing in Organizations that Learn*, Steven A. Cavaleri and David Fearon, editors. Cambridge: Blackwell Publishing, Inc.

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[i] Aaron™ is a highly configurable model of competitive dynamics and is published by LeapTec, 81 Hazard Avenue, Providence, RI 02906. Phone: (401) 467-9292. Fax: (401) 941-0412. The Service Quality Game is available from GKA, Inc., 125 Cambridge Park Drive, Cambridge, MA 02140 Phone: (617) 441-7766, Fax: 617-491-6744