Waters Center for System Dynamics
Trinity College of Vermont

ASSESSING PROGRESS IN SYSTEMS THINKING AND DYNAMIC MODELING: SOME THOUGHTS FOR EDUCATORS

Jeff Potash & John Heinbokel

SOME SHARED CONCERNS

Educators' interest in systems thinking and dynamic modeling has grown over the last few years, with curiosity having been piqued through a wide variety of introductory experiences. Many who have become familiar with systems thinking in "learning organizations" have approached systems as an instrument for organizational reform; others have interacted with commercial applications such as "Fishbanks" and are curious both about its internal workings and other available simulations; still others have come into contact with a colleague, either within their school or system or at a meeting, who builds or works with models and waxes eloquent about the "power of systems" within the classroom.

TALKING PAST ONE ANOTHER

The diversity of entryways is, of course, testimonial to the wide-ranging strength of "systems" to address educational needs. However, experience also indicates that people's disparate knowledge of and interest in systems translates into a veritable plethora of discrete and asystematic conversations which encourage cliques to form: recall the "Tower of Babel" which reminds us of the great danger in people speaking a multiplicity of tongues. Particularly where people are seeking initial guidance to assist them to learn how and where systems may be useful in education, the absence of a common tongue oft-times proves thoroughly frustrating.

MOVING TOO FAST WITHOUT PAYING ATTENTION TO WHERE YOU'RE GOING

I'm reminded that the situation parallels to a large degree the story of the urban dwellers who, with their fancy cars and hefty summer vacation budgets, flock to Vermont to experience its proverbial bounty of pastoral pleasures. Yet, on more than one occasion, the road has led to a steadily narrowing, unpaved, and rocky lane. Though the specter of the archetypical Vermont farmer, standing along the road offers an initial relief to the lost tourist, the actual conversation proves less than satisfying. One story has the city dweller, after having described the desired

destination site, being told by the taciturn farmer that "c'aint get there from here." A variation has the city dweller, asking if he could get to his desired destination by taking one or another roads, being told curtly by the farmer that he "don't quite know." When finally the tourist lashes out at the farmer in frustration, "Don't you know where you are?" the farmer responds, "Well, t'aint lost."

Getting lost is easy in systems and there are sufficient numbers of folks who've initially gotten excited, only to lose interest as the challenges of learning about systems loomed ever larger and more daunting.

MAXIMIZING SUCCESS

There are a couple of basic concepts which, albeit almost self-evident, nonetheless need to be made explicit:

1) Regardless of where one starts and where one hopes to travel, there remains a *learning curve*. Teachers need first and foremost, when interacting with systems, to picture themselves as STUDENTS trying to learn a new language and a new way to see things. Putting pressure on oneself to apply one's knowledge in a classroom and/or institutional setting without spending the requisite time LEARNING how to think and (if desired) model using system dynamics will invariably prove counterproductive. In sum, respect the learning curve and be patient!

2) *There is a hierarchy* of sorts which exists when trying to become a systems thinker and/or a dynamical modeler. This hierarchy dictates that one start simple, then gradually add complexity. "Simple" oft-times is uncomfortable because many view "simplification" as a dirty word. Those who equate expertise or mastery with complexity need to understand that the power of systems rests in starting simple and building gradually. What one will discover is that complexity is often linked with PARTICULARITY; that is, one adds lots of detail to address specific cases, not the general scenario. Recognize, having the power to build complexity will not necessarily facilitate communication between educators.

BUILDING BLOCKS TO SUCCESS

Having presented some basic overviews, it's time to address the generic HIERARCHY, through which one enters and, ideally, through which one passes while building a desired level of success.

I. UNDERSTANDING SYSTEMS THINKING

People who seek to build models or people who seek to effect organizational/institutional change have one common need: to develop a basic understanding of systems thinking; that is, what defines systems and makes them function. The key components (and the logical sequence for learning about them), which form the basis for what must be understood as a common language that will promote effective conversation, are:

A. Dynamic systems operate through FEEDBACK(S).

B. Feedback defines itself through behavior over time.

Once having mastered these concepts (no small feat, to be sure: recall, mastery means that one's understanding transcends the specific illustrations used to "learn" the concepts; in effect, one must demonstrate "transferability" in seeing systems behaviors beyond those with which one is initially familiar), one may choose to progress as follows:

C. Modelers need next to understand that dynamic systems incorporate two distinct components:
1.The movement of "stuff": Using the terminology of STELLA, STOCKS and FLOWS are at the heart of systems; these two operate in tandem to identify dynamic “stuff” which increases and/or decreases as it moves about, within, into, or out of the system in question.
2. Information controls the movement of "stuff": Again, in the parlance of STELLA, CONNECTORS move various types of information from STOCKS, FLOWS, AND CONVERTERS to define the rates at which stuff will flow in the system.

D. Once having conceptualized how and where the system functions, one then reviews and/or collects information with which to better appreciate the dynamic features of the system; its properties, leverage points, etc.

II. MODELING: RATIONALES AND OCCASIONS

Those interested in organizational behaviors and systems thinking may, at this juncture, choose to employ their knowledge of systems as a launching point for developing conversations around large and complex organizational systems without building models. This seems entirely appropriate, given desired costs and benefits; if relatively simple models aren’t useful for convincing others how actual systems are functioning, non-modeling activities can yield an acceptable cost-benefit ratio.

For those interested in developing models, care must be taken as well to nurture those skills. Armed with the knowledge that building models to simulate (not duplicate!) systems involves a learning curve, one needs to progress in a logical order to minimize frustration:

1) The objective for building the model needs to be understood from the outset. It is essential that one articulate, in 25 words or less, what objectives the model will be designed to address, before commencing model construction. Otherwise, one frequently finds him or herself sliding, either adding more and more com-plexity, or building a model which doesn’t serve its original design.

2) One must ALWAYS simplify at first -- to the point that one greatly OVERSIMPLIFIES how the system works. One stock, one flow, and one or two converters often initially suffice. The model, too, must work in this simple state.

*One must be able to acquire and incorporate information needed to define each factor to run a mathematical model of the feedback loop.

*One uses the model to simulate a systems behavior; graphical and/or tabular data generated must be understood.

*Model data are compared with one’s anticipated result; the output is used to ask new questions, make new predictions, and test these predictions by running more simulations or changing the model.

3) Complexity must be added carefully and gradually. Rapid enlargements of models translate into compounding problems and difficulty in problem-solving. Beware: grow the model slowly!

III. MODELING: INTERPRETATION

1) Models can be used to explain how a complex system works.

2) Models can be used to draw conclusions or make policy decisions

3) Models of one system can be used to understand how other systems work.

4) Models can identify shortcomings in our factual understanding of relationships.

IV. STRATEGIES FOR MAXIMIZING SUCCESS: CURRICULAR DEVELOPMENT

All educators share a common desire to communicate what they've learned with others. To avoid having ideas either dismissed as incomprehensible or, worse yet, as unrealistic, requires that one consider the following:

COLLABORATION: Models shouldn't be constructed as individual exercises. There are many dangers associated with working alone:

1) There is an often unwitting and unintentional propensity to interject personal assumptions and/or biases which jeopardize the value of one's work.

2) Two heads (or more) are better than one. Enough said.

3) Everything from framing a question on up to successfully building a model improves with explicit questions being raised and assumptions and presumed relationships being challenged.

In our experience there are four basic curricular roles that need to be filled in any successful model-building exercise; several of these roles can be played the same individual but a fully productive team of four can distribute these roles to individual team members.

1) Knowledge of the system in question: What are the Stocks, Flows, and Controlling relationships that characterize the system?

2) Technical modeling skill: How can the mental model best be translated to a computer simulation?

3) Pedagogic insight: How will the model be incorporated into the curriculum?

4) Constructive critic: This is the role that requires at least a second individual in each project.

INTERDISCIPLINARY EFFORTS: On a higher scale, collaboration focused on interdisciplinary topics requires all parties to COMMUNICATE how their systems work and to work toward developing projects which have the broadest potential to educate (I.e., to raise questions, develop unfamiliar connections between systems, etc).

V. CONCLUSION

All this is simply a guide for thinking about what one hopes to accomplish, within what time frame, and with what desire results. Knowing where one wants eventually to go and appreciating what it takes to get there will facilitate success, and accord one the means to avoid ending up on a one-lane dirt road with an uncooperative Vermont farmer as one's guide.

VI. GOOD LUCK!