Unleashing the Revolutionary Implications of a System Dynamics "Education" Using a "Ladder of Engagement"

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Abstract:

As self-described "educators," in our formal instruction of students and teachers and our more recent outreach to a wider array of clients, we have focused on systematically using the full range of system dynamics tools to become, and assist our clients to become, better thinkers and modelers. In a conscious effort to build that capacity through collaborative problem solving, we have devised a "ladder of engagement." It is a structure and sequence of activities supporting a powerful and integrated process by which continuously "better questions" allow us to: (1) probe progressively more deeply into describing the behavior of the system (a rung of KNOWLEDGE); (2) identify the system's features (feedback loops and delays) controlling its behaviors (UNDERSTANDING); and (3) locate and evaluate leverage points in the system where intervention can effectively and efficiently affect its behavior (INFLUENCE). In addition to the ladder's hierarchical structure, at each rung or level the process explicitly incorporates feedbacks designed to develop an iterative learning process that continually reinforces the linking of answers to better questions and the parleying of one's facility within a limited sphere of interest into broader abilities and motivations to pursue more diverse challenges and "enduring" and generic problems.

Introduction:

The professional domain of system dynamics (SD) is impressively broad. As a set of tools to aid in modeling diverse and potentially complex systems, SD, at one end of the spectrum, provides computer simulations with which to devise and evaluate policies for managing such systems, that is, to essentially discover answers to clients' questions or problems. At the other end of the spectrum, SD provides a tool-set to help structure reflection on and communication of divergent mental models, and in the process to support the synthesis of those mental models and the definition of additional, and hopefully better, questions.

As individuals who primarily identify ourselves as "educators," we have been struck, as have other practitioners with whom we have worked and learned, that while these can be distinct foci, they are not mutually exclusive dimensions of the field nor, for that matter, of the more generalized process of learning. For learning to have meaning, it must involve provide useful and useable "answers" for "real" concerns or problems. Yet it is equally important that these answers inspire "better questions," questions that effectively seek to extend the boundaries of what is known into the realm of what one desires to know.

Barry Richmond, both in his presentations and writings in the field as well as in his personal interactions with the formal "Education" community, asserted the unique possibilities extant in using system dynamics to inculcate what he described in 2002 as "systems citizenship." Integral to his thinking was a fundamental belief that system dynamics constituted a powerful language which could and should be accessed to solve immediate problems but, more broadly, to expand the capacity and motivation of students to ask new and better questions to address real world enduring problems. We have come to think of these as "three dimensional" or three "sector" problems that incorporate population, resource, and attitudinal components. By "growing" students' abilities to generate answers within a variety of curricular or disciplinary areas while inspiring them to build off of those abilities and confidence an interest in taking on more complex and challenging problems or questions, Barry envisaged that system dynamics could serve to revolutionize education.

That vision has helped clarify and reinforce a process that resonates with our own identification as "educator/practitioners." Fifteen years ago, our SD foundations were laid in efforts to utilize these tools as curricular aids to enhance college teaching and learning and, soon after, to provide training and support to K-12 teachers. Here we focused on the latter elements, emphasizing the enhancement of thinking and communication skills over the acquisition of solutions. We were gratified and rewarded when our students and colleagues generated more and better questions; solutions or answers were not so important. As we branched out into consultations on school organizational issues, the dynamics of community social services, and most recently into the analytical needs of the intelligence community, we were drawn more toward the answer-provision end of the continuum. Still, our educational foundations have obliged us to retain that educator's flavor of interaction with our new clients and to realize that a fundamentally common approach is equally useful both in those ostensibly educational and in those apparently consultative settings, and pays significant benefits with both audiences.

Our challenge, as we currently see it, involves treating all of our "clients," be they students, educators, social activists, or government employees, as students whose capacity for independent work we are seeking to enhance. It is clear to us that our desire to help them become better modelers, whether that translates into better thinkers or better builders of computer simulations, is part of a larger desire to help them develop a common or shared language with which present their mental models, to contrast them with those of others, to collaboratively synthesize better models, and to use those models to devise and evaluate policies for affecting the system in question. Building facility and confidence in their ability to more effectively manage systems of interest constitutes an important component of learning. We believe, however, and we have begun to structure this thinking into a process, that Barry Richmond's vision of systems citizenship must be organized around a process of asking better questions. In that spirit, we have developed and now use, working both as classroom teachers and as consultants and practitioners, an organized set of "better questions" that help guide a broader and more powerful process of learning.

We refer to our approach to collaborative problem solving as a "Ladder of Engagement" (Figure 1). It is an intellectual structure and sequence of questions and analyses that can be visualized as the rungs of a ladder supporting a powerful and integrated question-driven process by which we:

- Probe progressively more deeply into describing the behavior of the system (KNOWLEDGE).
- Identify the system's features (feedback loops) that control its behaviors (UNDERSTANDING).
- Locate and evaluate the leverage points in the system where intervention can effectively affect its behavior (INFLUENCE).

INFLUENCE
Am I (are we) able to devise an effective policy to affect the behavior of the system and to communicate effectively to convince others of its power?

UNDERSTANDING
Do I have (or we share) understanding of how feedbacks and delays control the way the system behaves?

KNOWLEDGE
Do I have (or we share) knowledge of how the system "behaves"?

FIGURE 1: Ladder of Engagement – Sequencing the "Big" Questions

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Those three points represent the core of what we seek to accomplish with our clients. The following two mutually reinforcing points are additional critical elements of **how** we **engage** our clients. As we climb that ladder together, we:

- Provide guidance on elaborating these mental models from initially simple depictions of core relationships to systemically richer, more complex, and realistic stories (ENRICHMENT).

- Develop shared insights through a set of tools and templates with which diverse stakeholders can effectively and respectfully express, explore, coalesce, and improve their respective mental models of the system in question (COLLABORATION).

In the remainder of this paper we will describe and expand on the three basic rungs of the Ladder of Engagement. It forms the basis of our work with a wide range of colleagues and clients to large degree because it offers a dependably fixed basic structure that is, on the one hand, sequential or hierarchical in its progression while, on the other hand, utilizing procedural feedbacks that foster refinement through iteratively revisiting rungs of the ladder. While that clear structure is reassuring, the Ladder allows for considerable room for variation and customization in the details of its application and for adjusting the number of iterations and loops performed before declaring victory and moving on to subsequent challenges.

Ladder of Engagement

Rung 1: "Knowledge" Do we share knowledge of how the system "behaves"? (Figure 2)

On the "Knowledge" rung of the Ladder of Engagement, we begin by working together to define and clarify the problem we are exploring. Even where considering relatively simple issues, defining the initial problem can often prove surprisingly challenging. Do we begin by identifying a "problem" that is evident at some specific point of time or space? e.g. Why was traffic so bad this morning? or Why do I not have enough accumulated in my bank account for that vacation I planned? Alternatively, perhaps the problem is best identified or recognized through observation of an evolving situation. Why has traffic been getting progressively worse over the past several years? or Why has my bank account been getting progressively smaller? Difficulties in explicitly articulating a problem in these "simple" cases are vastly increased for those wrestling with enduring and more complex real world issues. The propensity among many is to overlook this critical step. Without a a clear, open-ended statement of the problem, however, the next set of questions prove problematic.

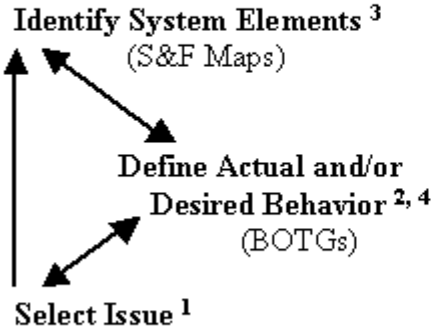
Given a problem statement, we next focus narrowly on the one or several elements of the system that is or are of central importance. We are challenged here to define the behavior over time of those elements. Ideally, we begin with simple, even simplistic, kernels of the system, so that we can maintain a collaborative and constructive approach to the exploration: How has the morning commuter traffic grown over the past couple years? With what pattern and amount has my bank account fallen? Are crisp quantitative data available or do we depend on perceptions of relative quantities? Most importantly, are we clear on what we are plotting and how it plots over time? If not, where are the problems and how can we reach agreement?

Here, again, the challenge of teasing out behaviors over time in a more complex real world situation typically generates "better questions" both regarding what is known and the relative importance or prioritization of that collection of knowledge. Oft-times, too, the process of developing multiple behaviors over time raises questions about what is unknown. In our experience that recognition, often focused on attitudes or behaviors, is a powerful reminder of the need to include these critically driving forces that are too often overlooked within a "system."

Next, we collaborate to translate these central behaviors into conceptual stock and flow maps. If traffic density has been changing, what process(s) or flow(s) would be adding to that density? What flow(s) could be removing traffic from the roadway? Can we define quantitatively those flows? What adds money to my account? What extracts money? Here we may not be in a position yet to explain why those flows are occurring as they are, but can we at least identify the flows or processes on which we will need to focus?

Finally, can we return to our Behavior Over Time Graphs (BOTGs) and project the timelines forward into the future, plotting one or more of what behavior we think is likely, what behavior we would like to see, or what future we dread?

FLOW DIAGRAM:



CRITICAL QUESTIONS:

1. **What system is of interest to us & which "problem" concerns us?**
2. **How has the system "behaved" in the past? Does this help to select or refine the issue?**
3. **What stocks and associated flows are likely to be important? (Revisit "Past Behavior"?)**
4. **How do we predict those elements will behave in the future?**

FIGURE 2: Structuring "Questions" to Bolster Knowledge

Rung 2: "Understanding" Do we share an understanding of how feedbacks and delays control the behavior of the system? (Figure 3)

Once we have a shared knowledge of what is important in the system and how it is behaving, we move to the next rung of the Ladder of Engagement to begin to explore what is controlling the behavior of the system. By "control," we primarily mean the endogenous feedback loops that, from within the system, control its behavior. Exogenous factors may influence the system, but the primary drivers, and those that we have control over, will be within the system.

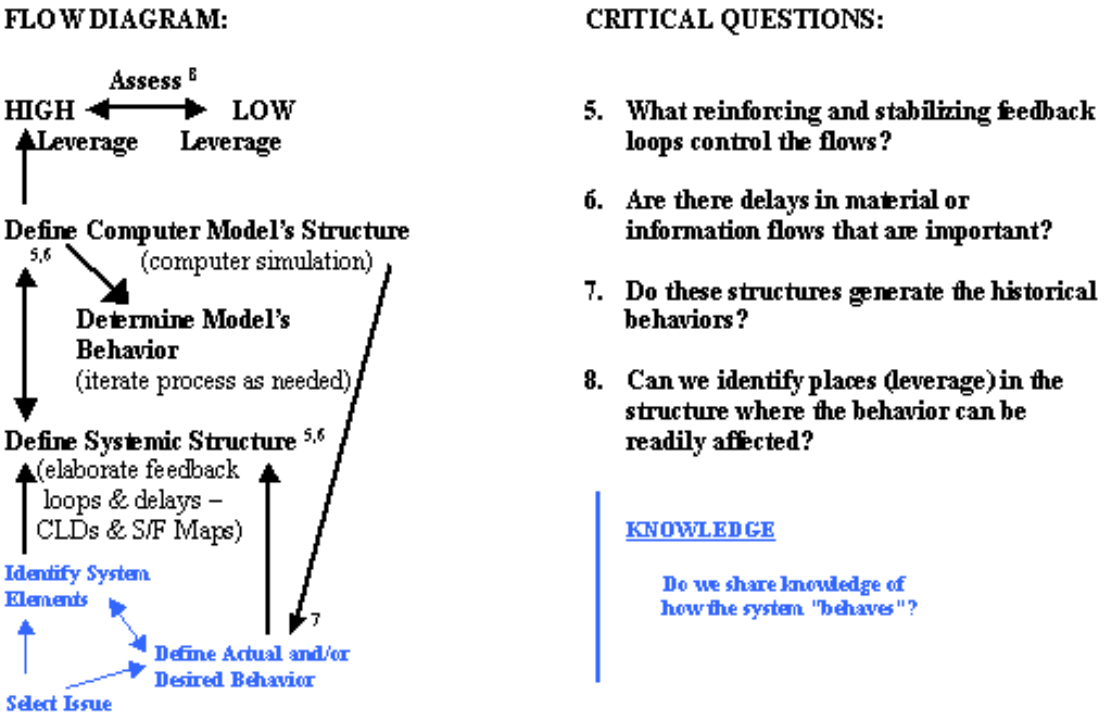


FIGURE 3: Structuring "Questions" to Bolster Understanding

For system dynamicists, all paths of knowledge lead to defining "systemic structure." There continues to be debate over the most effective means to capture and communicate, as a first step in understanding, the fundamental nature of feedback loops and delays. Causal loop diagrams (CLDs) have, in their most basic form, a power to communicate dynamics associated with self-reinforcing and balancing systems. At the same time, our experience has borne out the criticisms of many who acknowledge the frequent difficulties and even impossibilities in converting feedback loops into actual system dynamics computer models. Through such considerations, we have largely gravitated to the use of stock flow maps (S/F Maps) that explicitly distinguish between accumulations and rates.

Notice that in the figure we pose several critical questions for testing our understanding. The first pertains to the clients' ability to explicitly describe the fundamental feedbacks thought to define the system's behavior ("What reinforcing and stabilizing feedback loops control the flows?"). A second question involves the role of delays within the system ("Are there delays in material or information

flows that are important?"). Identification of various archetypical behaviors over time underscores the power of such delays (e.g., oscillatory behaviors, overshoot and collapse). Recognizing the existence of such behaviors constitutes a critical step in developing a deeper understanding of how the "system" is structured.

The true test of understanding, as Jay Forrester has frequently reminded educators, rests in their ability to build a computer model and simulate the behavior. All too often the model reveals, in its generation of unexpected behaviors, shortcomings in the builder's understanding. This is captured in our ladder in the "determine model's behavior." Notice that the model-generated output must be compared with the actual and or desired behavior and the question posed: "Do these structures generate the historical behavior?" To the extent that they do or don't, the process returns to defining the systemic structure, either for purposes of reevaluation (in the case where the model is recognized as flawed or incomplete), or, in the case where it provides "an answer," to begin to contemplate "better questions" involving expanding the model boundaries.

Once the model has been sufficiently tested and validated, it may be used to assess "leverage" within the system. "Can we identify places (leverage) in the structure where the behavior can be affected?" Notice that, while the model will be expected to identify "high" leverage policy options, it should also be able to illustrate why other options generate lower leverage. A model that advocates for one policy option without having tested and evaluated the efficacy of others suggests that the model builder was predisposed toward a particular answer rather than a more open-ended consideration of the best option.

Rung 3 Influence - Are we able to devise an effective policy to affect the behavior of the system and communicate effectively to convince others of the policy's power? (Figure 4)

The power of system dynamics rests in its unique ability to clarify and inform our ability to manage systems of interest and importance. Effectively influencing the behavior of the system is a two-step process:

1) We can use computer simulations to test and fine-tune our mental models of where the effective leverage for change can be found; and/or
2) We can use the systems tools available to us to develop and present effective arguments as we advocate the high leverage policies to a broader citizenry.

In seeking to operationalize these options, we again focus on "better questions." Formulation of a "plan of action" dictates that we consider the model's boundaries and its capabilities (and limits) for generating meaningful policies ("Do we understand leverage well enough to design effective policies?"). A second issue, critical for real world problem solving, involves comparing the model's recommended policy direction with alternatives ("Can we demonstrate that other policies represent low leverage?").

Once these two considerations have been satisfied, the challenge shifts to advocacy. How do we best use these systemic insights to communicate with others to advocate those effective policies? Knowledge without the ability or willingness to communicate and seek to convince others is, at best,

a purely academic exercise. To paraphrase Barry Richmond's thinking on systems citizenship: systems "thinking" without systems "doing" is altogether unpalatable.

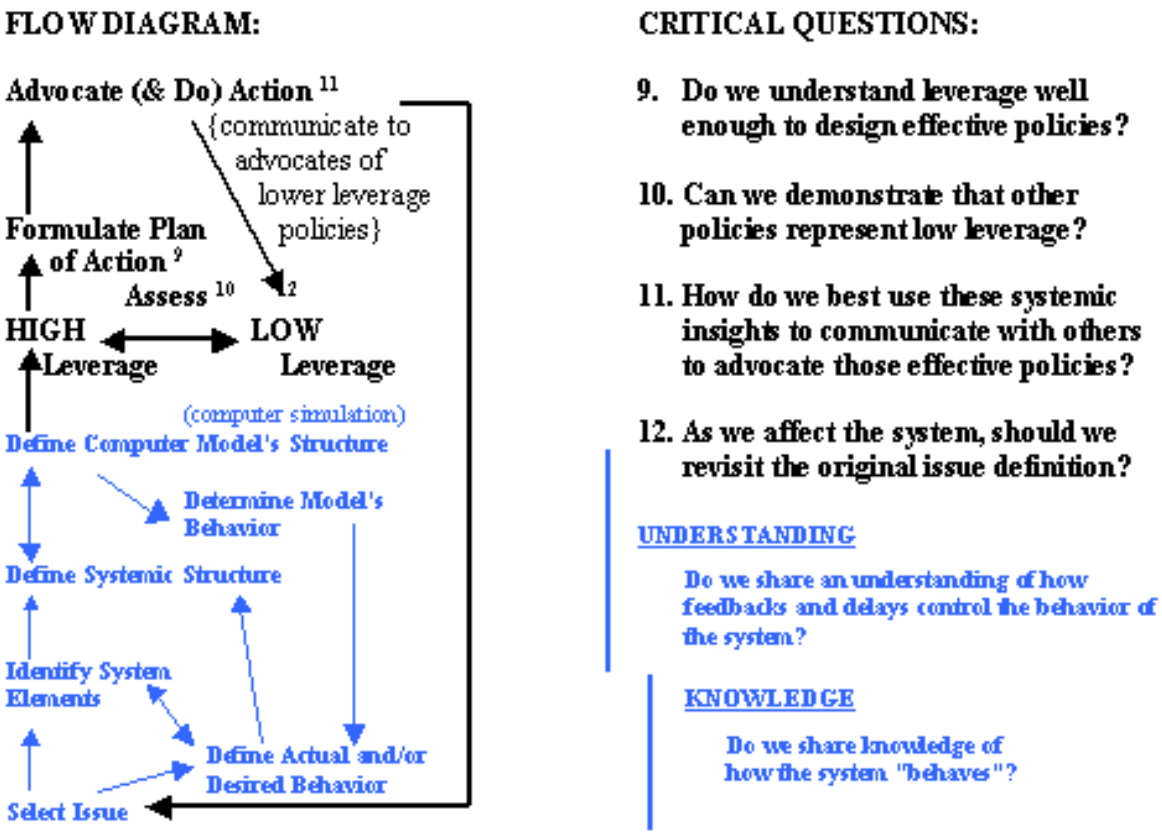


FIGURE 4: Structuring "Questions" to Bolster Influence

At the point at which system dynamics affords people the capacity to advocate for better policies, it also carries with it a "habit of mind" that remains true to our definition of true learning. Any particular answer should naturally drive the systems citizen to look beyond the boundaries of the model to contemplate and seek new and better questions.

Summary

A military analyst with whom we recently worked, eyed our 90+ page final report with a certain trepidation, and observed that he "supposed, with more time, you could have produced a shorter report." So it is with system dynamics, where the power of "elegant" modeling invariably proves far greater than that of brute force. "Simple" need not be misconstrued as simplistic.

With that concept as inspiration, we suggest that our experience as "Educators" and more recently as "practitioners" has guided us to seek better ways to inspire learning in comparable ways across the full spectrum of our colleagues and clients. Our "ladder of engagement" constitutes nothing more than a starting point for what we hope will be an extended conversation, linking a multitude of

audiences, often with very different immediate objectives, in a powerful rethinking of the role of better questions as a structure for releasing the truly revolutionary implications of system dynamics.

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