System Dynamics and Systems Thinking: It Takes All Kinds

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1. Abstract

Traditional System Dynamics modelers ("Complex Modelers") view with distrust the often simple but participatively-developed results of "Insight Modelers". Both types of quantitative modelers often regard "Systems Thinking" as dangerously incomplete, and irresponsibly advocated. Yet nearly all modelers will sometimes be dissatisfied with the substantial experience and resource commitments required to create an adequate quantitative model.

This paper suggests that Systems Thinking, Insight Modeling and Complex Modeling (and consultants and academics) each have their place within a larger system. This view arises from examination of the sales process, the technology diffusion process, and finally from analogy to the medical services delivery system.

A number of practices likely are hindering growth and quality of the field, broadly: 1) Ignorance of the broad range of practices and skills now a part of modern System Dynamics practice, 2) Blanket disparagement of other approaches and methods within System Dynamics, and 3) Hype—advocacy of one's own practice, without demonstration of effectiveness. Finally, the paper suggests that, following its own suggestions, quantitative modeling would be helpful in furthering the discussion on the growth of the field and balancing the various roles and practices within it.

2. Introduction

Many System Dynamics practitioners feel that their discipline should become a standard part of 21st century curricula and business life. Yet most practitioners are aware of the dynamics of fads. Many will remember the rise and decline of popularity of World Dynamics. Many will be fearing that Systems Thinking will follow the same trajectory, at some point falling quickly to oblivion, and in the worst case, taking much of System Dynamics with it. By contrast, we should discuss what it takes to cause rapid, uninterrupted growth in teaching, skill, and use of System Dynamics as well as Systems Thinking.

The related debate within our field tends to be simplistic: "approach A is correct; approaches B and C are flawed." Traditional system dynamicists, who build what we can here call "Complex modelers" often regard both Systems Thinking and "Insight Modeling" (which uses modestly-sized models and relies heavily on group learning in workshops) as potentially misleading. Systems thinking practitioners can fault quantitative modeling for its inaccessibility by normal managers. Insight modelers question the complexity of traditional System Dynamics models, again because of

accessibility. Consultants can point to academic's weakness in real-world modeling and implementation; academics can point to consultant's relative weaknesses in analytical skills and breadth of knowledge of cases and applications.

Ironically, such "debates" are usually not systematic, and seldom consider the dynamics of the field as a whole. Models of product or technology diffusion, such as (Bass 1969), (Homer 1987), and (Maier 1998) generally show that the success of products sold through their reputation requires both extensive word of mouth exposure (for which Systems Thinking is well-adapted), and continued tangible demonstration of product effectiveness (for which qualitative modeling is necessary). There is synergy here. In short, for maximum success in System Dynamics as in most ecosystems, it may be that "it takes all kinds."

The expression “it takes all kinds” is usually muttered upon seeing behavior or values quite different from one’s own. Indeed, the words are usually delivered whilst shaking the head with disbelief. But look at the words closely: they remind the speaker to remember that in order to make almost any organization work, be it an army, a church, a company, or a country, it takes all kinds of people.

In the realm of government, democracies value discussion and disagreement. But peaceful resolution should be valued perhaps even higher; Western democracies have the concept of the “loyal opposition.” It means that newly-elevated rulers, be they kings or prime ministers or presidents, no longer need to exile or liquidate their predecessor to assure prosperity and stability in the realm. It means that political factions no longer feel compelled by fear to wage war (literally) on one another. Perhaps it’s time to recognize the importance of differences within our own ranks as well, and the importance of mutually respectful, collegial discussion, which enhances the good of the realm.

3. Three Kinds, Two Differences

Let us first examine two of the divisions within our field. (There are doubtless more, not perhaps as visible; the continuing friction between academics and consultants comes to mind.)

Insight Models v Complex Models

A style of model and modeling which has gained popularity over the past 15 years is one we can call “Insight Modeling” even though it could equally be called “group modeling,” described in, e.g. (Vennix 1996) and (Vennix, et al. 1997). Most characteristically of the process, much of the model conceptualization and structuring is done in groups, with people from a client organization being fully active participants. The mutual learning that comes out of such efforts is admirable and desirable. As we know, even modestly-complex models can still yield interesting and counterintuitive insights, insights probably not attainable without System Dynamics modeling.

Insight Modeling, however, is limited to models of modest complexity. (Graham and Walker 1998) explore some of the limits of this approach: constraints on speed of modeling, number of people who can be involved, scope of issues addressed, and depth of validation. At a broader level, there is the more fundamental limitation of appropriateness for very important questions: Should the analytical basis for hundred

million-dollar decisions or billion-dollar decisions be limited to the number of feedback loops that can be conceived and understood by a small group of upper-middle-level executives? If your answer is "no," we could characterize your position as belonging to the "Complex Model" school.

Contrary to common perception, what makes most Complex Models complex is not disaggregated detail, but the breadth of scope, richness, and robustness of feedback interactions. These require a prior understanding of the feedback dynamics to be modeled adequately—it's not possible to do a good job modeling going directly from nothing to a final elaborate model. The path to a realistically complex model analysis often in fact starts with 1) a Systems Thinking-type diagramming exercise, then progresses to 2) a modestly-sized Insight-type model. Only then are the issues and the complexities clear enough for 3) construction of a reliable and realistically complex model. (Lyneis 1998b) describes how this sequence works in practice.

So Complex Modelers by and large are familiar techniques of Insight Modelers and Systems Thinkers, but the reverse is unfortunately rarely true.

Qualitative vs Quantitative models

An even more fundamental debate takes place over Systems Thinking approaches to problem-solving, which don't even quantify relationships before drawing the conclusions, which are based on relatively imprecise diagramming. There is now an established body of literature and indeed, a conference circuit for Systems Thinking. It is extremely popular and probably better-recognized by the general public than System Dynamics. And there is remarkably little cognizance by Systems Thinking aficionados that related quantitative modeling is even possible, let alone routinely practiced. (This is in distinct contrast to many leaders in the field, who were trained in Complex Modeling or Insight Modeling at MIT and elsewhere.)

The thought of drawing actionable conclusions from diagrams alone is profoundly disturbing to many System Dynamics modelers of both the Insight Modeling and Complex Modeling persuasions. Time and again, System Dynamics modelers see their understanding of policy implications shift and evolve in parallel to the modeling work. So the pitfalls of never checking one's thinking through quantitative modeling are palpable and compelling to those with experience in building realistic quantitative models. Discussions of qualitative vs quantitative feedback modeling in the System Dynamics field predate *The Fifth Discipline*, e.g., from (Wolstenholme and Coyle 1983) to (Wolstenholme 1999), but these have not engendered the attention and discussion the issue deserves.

Finally, System Dynamicists and Systems Thinkers alike are aware of the dynamics of fads. An appealing idea can spread very quickly, especially within the business community. Inappropriate and unskilled applications of the idea can follow nearly as quickly. As news of failures in practice spreads, the early popularity turns into common knowledge that the ideas don't work—***regardless of their intrinsic merit***. This has been the fate, for example, of TQM, despite clear evidence that it does work well when used well: "Everybody knows" that it doesn't work. So there is the apparent danger of Systems Thinking doing major damage to the reputation of System Dynamics.

That being said, most problems are not billion dollar problems, and cannot come close to justifying a full-scale Complex Modeling effort, or even Insight Modeling. Is it not equally inappropriate, a Systems Thinking advocate might well ask, to simply walk away from problems that won't (for any of several reasons) ever get decent quantitative modeling? Indeed, the Systems Thinking work at MIT was started as a continuing experiment in ways and means of bringing some of the fruits of System Dynamics (and other learning disciplines) to be accessible by individuals, without extensive training and degrees. How can the benefits of System Dynamics be thoroughly spread into society if a Ph.D. and years of experience are required?

4. Differences Have Serious Implications

Are there documented cases of Systems Thinking clearly misleading the people using it? The good news and the bad news is that applications of System Dynamics and Systems Thinking are diverse enough that little overlap has occurred, at least to the authors' knowledge. The only complete case we know of where a Systems Thinking exercise has been followed by intense quantitative modeling was Callaghan and Park (1998). In that case, the Systems Thinkers were extremely experienced System Dynamics modelers, and the conclusions were drawn both systematically and conservatively. The qualitative conclusions weren't contradicted by the subsequent quantitative modeling, although it yielded considerably broader and more precise conclusions.

But the potential for badly erroneous conclusions exists. Consider two case studies, the first a Systems Thinking approach to implementing change in the US Navy (Systems Thinker 1998):

> Recognizing that success begets success, the…reform team sought to create—and then promote—early successes. The "Communications Success Loop" shows the importance of carefully selecting initiatives that have a high probability of success; an initial success can trigger a "virtuous" reinforcing loop, while a failure can cause the loop to run in a "vicious" direction.

Now consider a second study of implementing change in a semiconductor company, this time a relatively well-validated quantitative model (Sterman et al. 1997):

> Early results are widely advocated to demonstrate the validity of a program, kick-start diffusion and boost the virtuous cycle of commitment and effort (Shiba et al. 1993). On the other hand [the model analysis shows that] a focus on quick results biases decisions against innovations with long time delays and leads to myopic resource allocation. Focusing on early results may lead to excess capacity, financial stress, downsizing and the collapse of commitment to the program. Improvement programs can fail not in spite, but precisely because of their early success.

Now it is clear that there are important differences in the contexts for the two studies—the US Navy will not be surrounded by the same feedback loops as a semiconductor company. But it is equally clear that if the qualitative study had been performed on the semiconductor company, it almost certainly would have missed the structural elements and feedback loops that turned out to be critical to the behavior and policy implications.

Indeed, it is relatively common to discover key structure and feedback loops even late in the process of model calibration. For example, (Lyneis 1998a) describes modeling to forecast cycles in aircraft orders (to the extent theoretically possible). In that effort, they discovered through calibration that a previously-neglected factor—the rise of aircraft leasing—was a major factor in creating an unprecedented (and difficult to forecast) surge in aircraft orders.

So at least within the Complex Modeling community, it is commonly held that it is extremely unwise and potentially damaging to embark on a Systems Thinking exercise for an important problems without the intention of immediately embarking on quantitative modeling to gain a certainty commensurate with the stakes involved.

5. It Takes All Kinds (To Get To Market)

For an individual practitioner, we can perhaps conclude that the only true methodological flaw is failure to ensure that appropriate techniques are brought to bear on a problem. But there is a second level of conclusion as well, in the arena of System Dynamics and Systems Thinking as part of a larger system—the production and consumption of systems-based ideas, insights, and results. We need to return to the theme of "it takes all kinds."

Consider the simple microcosm of someone within an organization deciding to use System Dynamics or Systems Thinking. What in the environment will help that process along or retard it? Salespeople sometimes use an acronym, AIDA, to describe the sales process. The acronym stands for Awareness, Interest, Decision, and Action. The relevant point for the present discussion is that different kinds of information are needed at different points in this process, as Figure 1 below illustrates.

In the Awareness phase, publicity counts for a great deal. We shouldn't need to remind anyone of the tremendous surge in publicity created by Peter Senge's *The Fifth Discipline* for Systems Thinking and indeed System Dynamics. This kind of publicity is very difficult for, e.g. academics or complex modelers to generate, due to a very different orientation, skill set, and body of experience. It takes all kinds.

In the Interest phase, we've found it helpful time and again that someone inside an organization says "yes, we studied that in school; it's real." They have personal knowledge, however sketchy of System Dynamics or Systems Thinking, and that internal legitimization moves the whole process of convincing stakeholders forward. Who creates that personal knowledge? It's not the publicity efforts—their contact isn't at all personal, or is it distinguishable from a fad. It's academics and workshop leaders. They end up teaching and giving confidence to vastly more people per annum than a complex modeler. It takes all kinds.

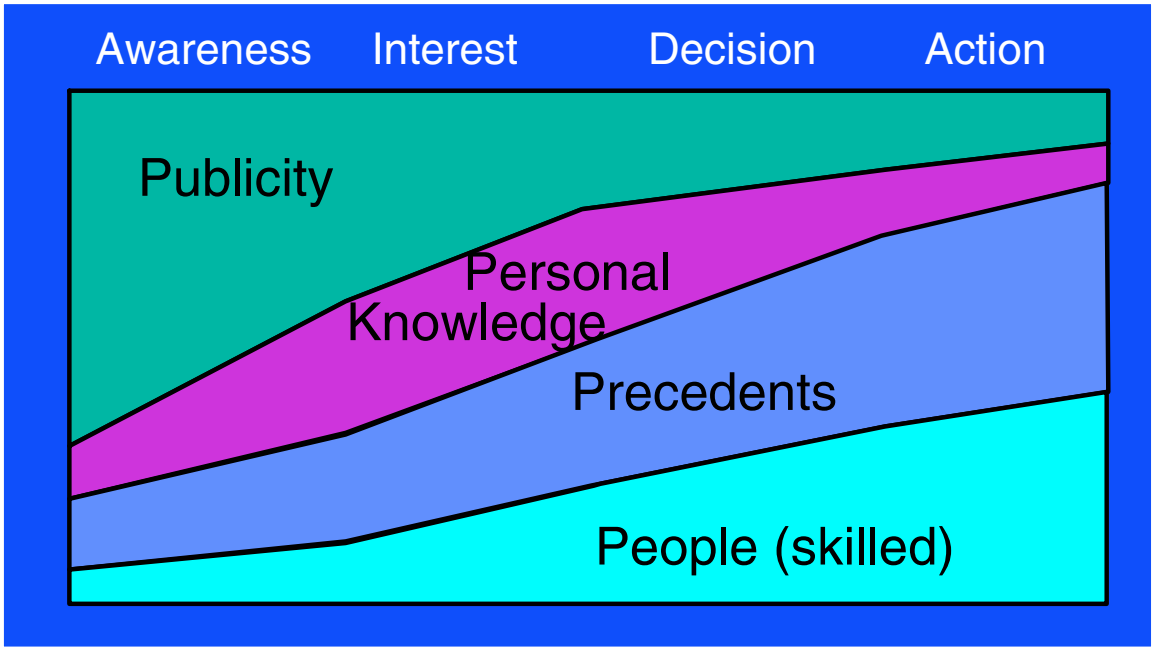

Figure 1. "Ingredients" required at different phases of the sales cycle.

The existence of precedents is also extremely helpful---the demonstration that this stuff not only works in the abstract, but works in your industry, on problems like yours. The modeling schools that create the largest volume of success stories are going to be academics and others doing Insight Modeling, simply by virtue of sheer volume. Someone who does an Insight Modeling workshop every two weeks can create twenty five times as many cases as a complex modeler doing year-long projects. But at the same time, at least some of the success stories need to be clear-cut and unequivocal demonstrations that not only did someone build a model and succeed, someone *had to* build a model to achieve the kind of success they did, and that takes the kind of in-depth analysis that only comes from realistic Complex Models. It takes all kinds.

Finally, when it comes to deciding and acting, it's important to have people available that can do the Systems Thinking or the System Dynamics in practice. Academic training isn't enough, no matter how thorough-going. To do an engagement reliably takes several years of experience and exposure. Such experience is usually found only in consulting companies. Moreover, as modelers who have experienced both Insight Modeling and Complex Modeling, we suggest that becoming truly skilled at Insight Modeling or Systems Thinking requires experience at Complex Modeling as well. Note that many of the most illustrious practitioners of Insight Modeling and Systems Thinking in fact trained and practiced in Complex Modeling at places like MIT and Pugh-Roberts. It takes all kinds.

6. It Takes All Kinds (To Build an Infrastructure)

To move away from the anecdotal and more toward the analytical, consider the causal diagram below in Figure 2 that relates the different resources and activities within the "System Dynamics system." If the AIDA model in Figure 1 shows how the state of the field influences the sale of new modeling activities, the causal diagram in Figure 2 "completes the loops" by showing the variety of ways that modeling activities build the infrastructure of the field.

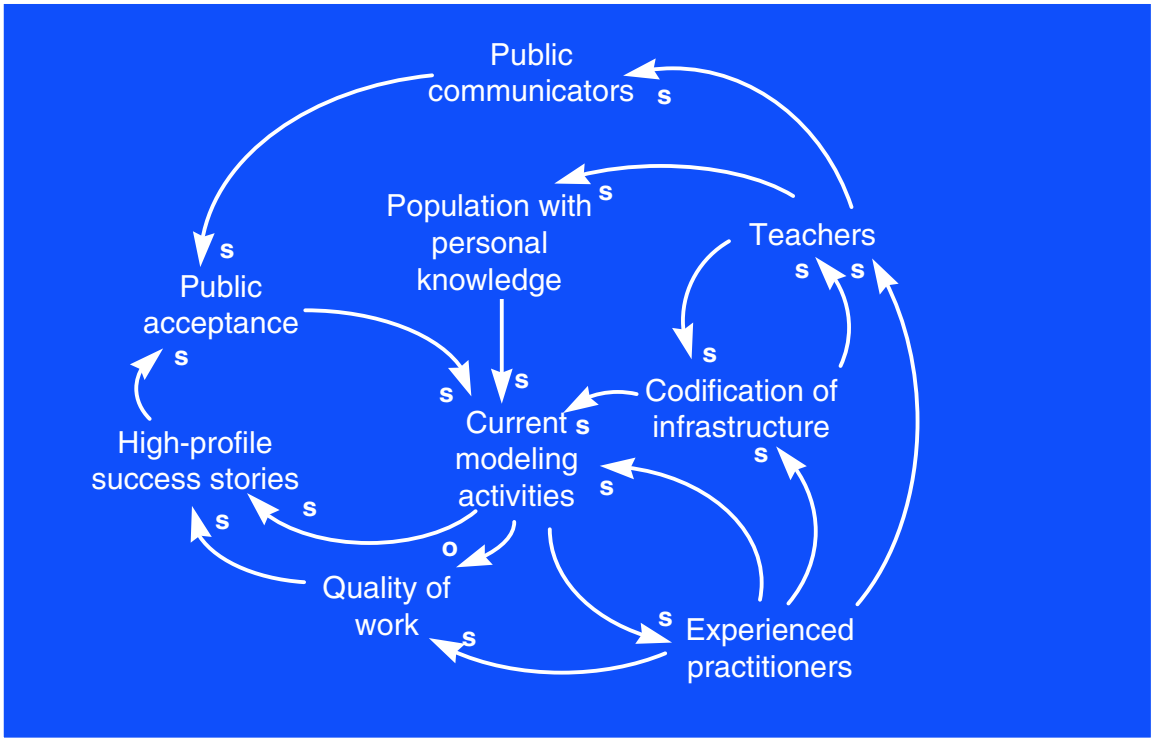

Figure 2. Causal diagram of resources influencing society's use of System Dynamics and Systems Thinking

Two observations: The "current modeling activities" has many inputs, and the nature of those inputs is probably nearly multiplicative. For example, with zero public acceptance and zero personal knowledge about System Dynamics or Systems Thinking present, the current modeling activities will be ceteris paribus zero or not far from it. This contrasts with the case where there are a balanced set of inputs we talked about in the AIDA selling model. So the flow diagram again formalizes the proposition that "it takes all kinds."

The second observation: Most of the loops in Figure 2 are positive, or self-reinforcing. They are all capable of working in either direction. There is only one "opposite" effect on the diagram, where more modeling activities, with the same level of experienced practitioners, reduces the quality of work. The diagram suggests that poor quality work can turn the positive loops into vicious circles, creating the sort of fad dynamics that have nearly done in TQM, for example.

7. It Takes All Kinds (To Respond to Many Needs)

Consider the collection of professions shown in Figure 3 below.

First, we observe in Figure 3 an orderly progression of patient care, indicated by thick arrows around the outside. The simplest injuries are dealt with by First Aid, which millions of people are trained (or have learned) to do. Quickly-developing, life-threatening situations are dealt with first by Emergency Medical Technicians in ambulances. Stabilized but challenging conditions are dealt with by physicians, specifically internists or general practitioners. The most challenges cases then go to surgeons and other specialists.

Figure 3 also shows systematic interaction with universities, where medical activities of all kinds are studied, and best practices and new findings are continually fed back to the various professions.

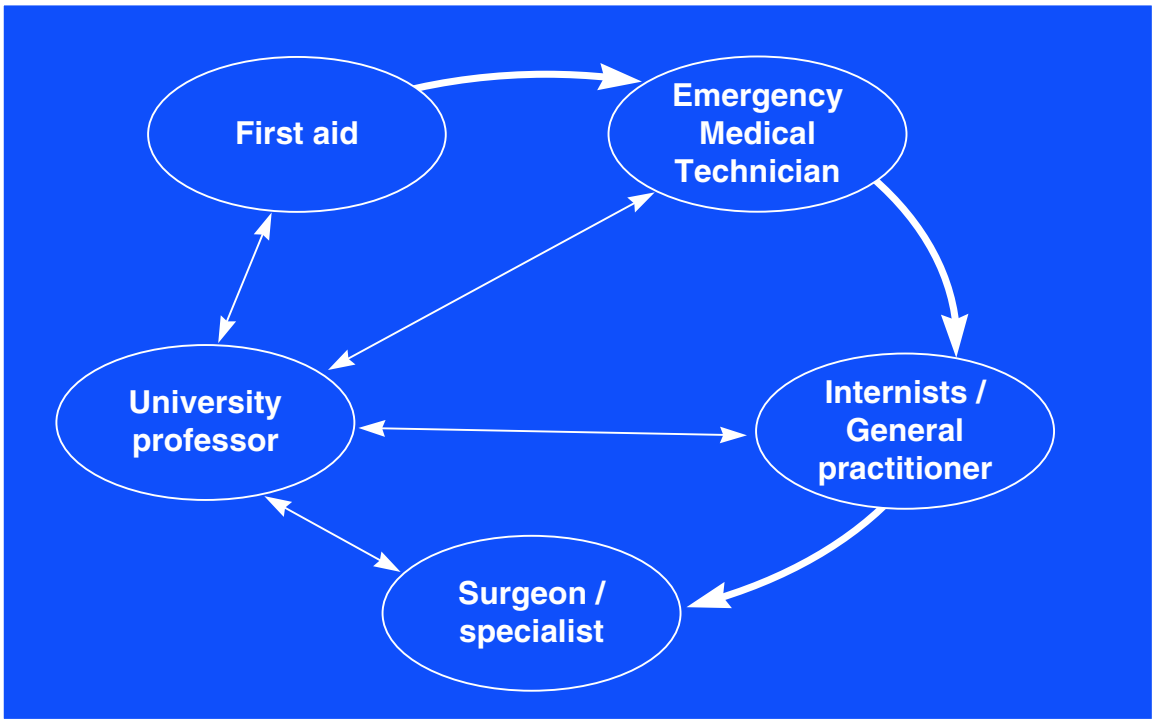

Figure 3. "It takes all kinds" to run a health care system.

We can suggest approximate analogies to the various "systems" disciplines.

- The high-stakes, high skill, resource-intensive world of the surgeon corresponds to Complex Modeling.
- The more frequent activity is for lower stakes and less resource-intensive care, which corresponds to Insight Modeling.
- For very quick action, there are the focused skills of emergency medical technicians—the ambulance crew, just as there are skilled facilitators who use Systems Thinking to quickly defuse dysfunctional executive interactions.
- Finally, there is self-help or treatment by non-professionals, which was and perhaps still is the goal of Systems Thinking as used by executives and other corporate employees.

8. What All Kinds Don't Need

Rather than pontificate specific requests of specific groups, let us, hopefully with a modicum of humor and charity, suggest a top-ten list of things the field would be better off without:

1. Systems Thinkers ignorant of the existence of System Dynamics. They exist, and in large numbers, blissfully plying their trade ignorant of both the pitfalls of exclusively qualitative modeling, and a cure for them. (As noted above, the situation is quite different for many of the leaders of the Systems Thinking movement, who are "classically trained" in qualitative modeling.)

2. Systems Thinkers failing to point out System Dynamics as an available follow-on. This is roughly equivalent to the ambulance driver saying "what hospital? We've got everything you need right here."

3. Hype--Failure to distinguish between experimental methods and proven practices. Consultants of all persuasions will continue to be in bad odor with academics until they are clear about the credentials of what they're practicing, specifically whether there are clearly documented successes. The business community tends to accept new ideas even without proof at first, but then rejects them if they fail to live up to the hype. At some point, advocacy without testing the hypotheses (e.g. "the Systems Thinking approach reliably creates tangible benefits") moves from "new experimental thinking" to hype.

4. Professional Systems Thinkers without training in System Dynamics. Facilitative skills, causal diagramming, and archetypes can move a group of decision-makers to the point of agreeing that a set of issues has been captured. No System Dynamics background is needed thus far. But taking action still requires drawing conclusions from a complex set of interactions. Conclusions are far more likely to be correct if the facilitator has been exposed to similar systems for which conclusions have been rigorously tested. That is, the facilitator is much more likely to elicit correct conclusions with training in qualitative System Dynamics modeling.

5. System Dynamics curricula without explicit training in facilitated model conceptualization and construction. Facilitation expands the simplest modeling skills into two important areas: general consultative and leadership skills, and conscious modeling process. The alternative to training in facilitated modeling is many years of trial and error to acquire a primarily unconscious modeling skill. This is not only inefficient for individuals, but creates a permanent quality problem for the field, as younger practitioners will not have fully developed the needed modeling and leadership skills.

6. Ph.D.s in System Dynamics with no experience in Complex Modeling. Specifically, Ph.D.s should have an experience of constructing and thoroughly validating a realistically complex model, operating in a team, and packaging results for non-dynamicists. How can one master a subject experiencing no more than the students?

7. Insight modelers denigrating Complex Modeling in general. At least until someone shows us a five-level model on whose policy predictions they're willing to bet several hundred million dollars on.

8. Quantitative modelers denigrating Systems Thinking in general. Disparaging something, even when using it as part of one's toolkit seems inconsistent, bad manners, and bad Public Relations for the field.

9. Regarding delivery of model analysis results as the final stage in helping an organization. Modelers who only "throw results over the wall" often fail to actually produce improvements, and fail to maintain a reputation for practicality and value. A higher ideal of modeling practice is direct and seamless follow-through to implementation, preferably supplying the additional expertise required in this separate realm. This means that modelers, be they consultants or academics, need to engage some organizational change and consulting skills as part and parcel of the modeling

process. Only thus can the modeling be counted on to do some good, and only then can the field build a reputation based on tangible accomplishments.

10. Erecting barriers between consulting and teaching. Academics are often blind to the management and consulting skills that surround a consultant's modeling skills. Consultants often fail to appreciate both the grasp of the SD literature and other fields of knowledge, and the critical thinking skills required of successful academics. If these blind spots are allowed to cut off continuing contact and learning, there are great difficulties incorporating real-world priorities and experience into curricula. There are also great difficulties introducing truly rigorous thinking and institutionalized learning into consultative activities. The object of academic activities shouldn't be solely to create more academics. There needs to be some contact with actually being able to make a difference in "the real world." The object of consulting shouldn't be just to make money; there's a learning infrastructure that needs continual maintenance. In the long run, "it takes all kinds."

9. Is This Systems Thinking Exercise Satisfactory?

One final note. Up to this point, we've discussed some issues, drawn three diagrams, and drawn ten conclusions. Among those conclusions is the proposition that, for sufficiently important problems, simply drawing some diagrams and drawing conclusions isn't an appropriate point at which to stop the analysis.

Complex modelers may have noted already that the causal diagram above has a multitude of positive loops and only one negative loop. Often, that's a sign that the modeler hasn't yet recognized many of the constraints and negative feedbacks that determine strategic success and failure. The conclusions from the diagram are almost certainly incomplete, even if the limited conclusions are true.

It therefor would be particularly appropriate to go further, to model the development of our field quantitatively. In April, Jack Pugh, acting as President of the System Dynamics Society, sent out a general announcement that began:

> The System Dynamics Society has been in existence 13 years. We have achieved most of our initial priorities. Now it is time for the society to review the purposes for which it was organized and perhaps to set new priorities. Participation by the whole society necessary if we are to generate as many new ideas as possible and for the membership to "own" the new goals that come from this process.

Developing a quantitative model would serve two purposes:

- Create an explicit dialog among the multiple stakeholders in the field, many of whom are not well represented in the System Dynamics Society and its conferences
- Create an explicit process for the Society to consider strategies and tactics going forward

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