An Approach to Teaching Systems Thinking for Public Sector Audiences

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This paper describes a series of curricular components necessary to teach systems thinking to public sector audiences. These components fall into three categories: (1) theory and concepts, (2) problem solving tools and heuristics, and (3) pedagogical materials. The paper is based on work creating a course entitled "Systems Thinking in the Public Sector" at the Rockefeller College during the spring semester 1997.

System Dynamics at Albany. In order to meet teaching requirements, a course in Systems Thinking in the Public Sector at Albany needs to respond to a number of design requirements:

- To teach principles of model-based issue finding, including how to distinguish feedback-oriented problems from other types of well-structured modeling problems
- To teach how to do qualitative feedback-oriented analysis in its own right (i.e., without formal simulation support)
- To serve as a front end to more formal model-building courses (we have three formal model-building courses at the masters and Ph.D. level)
- To link to coursework and research at Albany on mental models and how human judgment fits into managerial decision making about dynamic systems
- To link to the work of Senge (1990) as a pre-model-building but model-based course
- To link to the public sector literature on strategic planning in the public sector (e.g., Bryson 1995) and the redesign or "reinvention" of government services and operations (Osborne & Gaebler 1992; Osborne & Plastrik 1997).

Part I: Basic Theory and Concepts

Feedback and Feedback Thought. Divergent approaches to systems and systems thinking currently abound (e.g., *System Dynamics Review* special issue on Systems Thinkers, Systems Thinking, 1994). While we believe that students need to be exposed to the diversity of approaches to this topic, we also believe that our coursework should be focused on feedback and dynamics, emphasizing the special challenges that face public policy analysts and managers who struggle with the dynamics of public policy systems. Conceptually we tie our work to the servo-mechanism thread of feedback thought as identified by Richardson (1991). The key theoretical point of the course--the assertion that dynamic behavior is a consequence of feedback structure (feedback loops plus stock and flow structure)--is taught using the Beer Distribution Game in the first class of the course and emphasized throughout. This conceptual and comparative systems material needs to be presented early on in a full semester course.

Mental Models. An abundant literature exists on how human judges and experts perceive and make decisions in the public sector (Hammond 1996; Rohrbaugh 1992; Andersen & Rohrbaugh

1992). In addition to being exposed to feedback as a body of theory about the external policy environment, we believe that students of systems thinking need to be grounded in an explicit theoretical view of what constitutes a mental model and hence how these mental models can be improved. We teach the view that mental models contain stories with characters (stakeholders) taking actions (policy levers or means models) to achieve their goals (ends models) guided by understandings of how means are connected to ends environments (Richardson et al. 1994; Andersen & Rohrbaugh 1992).

Simulation Models Support Feedback Thinking. We teach that the primary motivation for systems thinking approaches is the disconnect between our means-end theory of how expert and human judgment functions and a servo-mechanistic theory of organizations for public policy systems (Sterman 1994). Central to our formal theory of mental models is the emerging hypothesis based on preliminary experimental work by Richardson et al. (1994) that the final results of systems thinking projects must be "chunks" of dynamic insight. Our coursework emphasizes that systems thinking projects can support a diversity of decision support objectives ranging from simply allowing participants in the process to see where they fit into the overall system to achieving high level insights about how the dynamics of a system are linked to its feedback structure. We are agnostic about the possibilities of teaching higher level insights without formal modeling support (Forrester 1994).

Wicked Puzzles in the Public Sector. A problem that we routinely face in advanced modeling courses is that neatly packaged problems involving dynamic complexity rarely present themselves in the public sector (indeed in any sector). Weimer (1991) has proposed that puzzles in the public sector can present wicked conundra because they co-mingle conflict, uncertainty, and complexity. Since our systems tools are tuned to solving problems involving dynamic complexity (a subcategory of three classes of wicked puzzles in the public sector), we teach first the types of puzzles in the public sector and second some of the theoretical reasons that these puzzles arise.

True dynamic complexity, the stuff that system dynamics is best suited to, involves stock and flow dynamics, feedback dynamics arising from the loop structure of a system, and an ability to disentangle endogenous from exogenous dynamics. In addition to dynamic complexity, public policy systems contain detail complexities, goal conflict and lack of clarity over action set preferences. All of these types of complexity must be disentangled from issues relating to conflict between stakeholders and uncertainty (randomness) in the policy systems themselves.

Morecroft (1985) has discussed bounded rationality as a theoretical reason why dynamic complexity can arise from local pockets of organizationally or cognitively bounded rationality. Policy and managerial systems in the public sector generate dynamic complexity for a number of special reasons that are related to how programs are organized in the public sector. Right from the start, our form of constitutional democracy requires a separation of powers in government that mandates pockets of bounded rationality that do not speak to one another (i.e., goal setting takes place in the legislature, program design with one sector of the executive, fiscal control in another, control of public personnel in yet another). Osborne and Plastrik (1997) have focused on these bureaucratic sources of complexity in their latest work on transforming the public sector.

From this initial focus on constitutional democracy emerges naturally a need to implement programs through inter-governmental networks (local agencies implement policies mandated at the federal or state level) involving inter-agency networks (social services, substance abuse, and mental health may all treat members of the same client base). Our students need to appreciate more fully these theoretical sources of dynamic complexity that are unique to the public sector.

Multiple and Fragmented Decision Arenas in the Public Sector. Public and private sector problems alike can be addressed and solved in a variety of what we call decision arenas. For example, a task force drawn from within a single organization sitting down to analyze and solve a problem forms a very different decision arena than an individual CEO or member of the legislature sitting down on his or her own to think through the problem. Other problems are addressed by a group drawn from across a network of participating agencies who all share an interest in the problem being solved.

Public sector applications are often addressed in several decision arenas that do not exist in the private sector. The legislative process is key to policy making in the public sector and the dynamics of decision support in that environment are very different from those in any corporate board room (see, for example, Andersen 1990). In addition, judicial decision arenas, the press (due to Freedom of Information legislation) and intergovernmental forums shape decision arenas that are unique to the public sector. Our students must survey and understand the diversity of decision arenas that must grapple with dynamic complexity in public policy systems.

Decision Support Goals. Because public sector problems arise from such a diversity of complexity, conflict, and uncertainty and because such a diverse set of decision arenas exist in the public sector, we believe that our students must be able to focus on a diversity of quite different decision support goals for a modeling or system thinking project. We believe that four classes of decision support goals exist. At the first level, participants will be able to view and understand the full set of characters and stakeholders within the system, position themselves within the system, begin to shift from "they" to "we" to "I"-based stories about the causes of system problems, and envision easily argued means-to-ends policy interventions. At the second level of decision support goals, participants can appreciate simple stock and flow dynamics, can argue through the consequences of a simple positive or negative feedback loop, or can appreciate how a system archetype may be working in a system. Level II insights typically do not involve formal simulation. Level III insights are these that involve true dynamic complexity that can probably be envisioned by an experienced modeler, but for which a formal model is needed to communicate the insight to a participant team. Level IV insights (these are rare in our work) are dynamic insights that an experienced modeler would need to use extensive formal techniques to extract from a model before transmitting to a client group (e.g., Mojtahedzadeh 1997). At a theoretical level, we believe that our students need to appreciate this hierarchy of decision support goals before they become involved in extensive project work.

Part II: Problem Solving Tools and Heuristics

Because problems in the public sector involve additional sources of complexity, because an additional set of decision arenas complicates analysis, and because decision support goals can be so

diverse, we believe that a wide set of problem solving tools and heuristics must be applied to analyzing these problems. While our core toolset comes from the system dynamics and systems thinking literature and approaches, we believe that other problem finding and focusing approaches (e.g., Bryson 1995; Osborne & Gaebler 1992; Osborne & Plastrik 1997) must also be integrated into the analytic process, especially the early problem definition and clarification modes.

Heuristics and Tools for Problem Definition and Clarification. Before a team aspires to complete a systems thinking exercise, a range of tools that can sort out various types of complexity, conflict, and uncertainty needs to be applied to focus the problem. The techniques that we teach include: broadly-based problem finding scans (e.g., Hopes and Fears exercise), stakeholder analysis (various types and forms), goal hierarchy mapping, action set elicitation, and goal-by-action set maps that show how participants believe that basic action sets are related to overall system goals. These problem defining tools are very similar to strategic planning tools used in the public sector (Bryson 1995; Andersen, Belardo & Dawes 1994).

Core Dynamic Thinking Tools. During the spring 1997 semester, we taught the core dynamic thinking tools using techniques that fell into the three usual system dynamics categories of structure, behavior, and structure-to-behavior links. Table 1 below illustrates the range of tools used in these sections of the course. The topics above the shaded line are qualitative systems thinking tools and were emphasized in the course. The topics below the shaded line belong to the domain of our model-building curriculum and were not taught in the spring course.

Table 1: Conceptualization of Feedback and Dynamics in the System

Endogenous Causal Structure (Feedback Loops)	**Structure-to-Behavior Links**	**Dynamic Behavior**
• Identify Key Stocks • Stock-and-Flow Diagramming • Causal Loop Diagramming Goal-gap Heuristics Ratio Heuristics • Apply System Archetypes	• Naive System Stories • Apply System Archetypes • Complete the Reference Mode Exercise • Action Set vs. Goal Matrix • Goal Conflict Matrix	• Reference Mode Sketches Key Variable Heuristic • Complete the Reference Model Exercise
Formal Model-Building Steps, etc.	Policy Simulations and Models Analysis, etc.	Simulation Generated from Formal Model, etc.
Loop Analysis Routines, etc.	Pathway Participation Routines, etc.	Formal Tools for Analyzing Simulations

The class spent some time developing heuristics that could aid students in drawing reference modes and causal loop diagrams from structured case materials. These experiments were half successful. This curriculum development effort needs to be continued.

Deciding Whether or Not to Simulate. As one part of the class, students were required to work up a systems project drawn from their personal work. Interestingly, not all students were able to identify problems that yielded interesting dynamic complexity. A problem might reduce to inter-

regional conflict between competing stakeholders, without any appreciable feedback. However, when problems involving feedback dynamics were discussed, the question invariably arose of how far could qualitative analysis go before simulation would be needed. A course such as this one needs to be model-based, but not a model-building course, so that students can gain appreciation for the power of simulation as a decision support tool in supporting systems thinking. This will necessitate spending more time than we did this last spring on the question of when and whether or not to simulate a problem.

How to Derive "Chunks" of Dynamic Insight. Perhaps the most challenging portion of the spring course centered on teaching the concept of "chunks" of dynamic insight. We were working on the explicit hypothesis that in order to transfer useable insights to the mental models of management teams, the modeling team would have to create high level insights that summarize the action and policy insights of the systems thinking intervention. This proved to be a very hard concept both to describe and to teach. Some student projects resorted to creating slogans that captured the essence of some problem, but might not carry any insights about the dynamics of the problem.

One approach that proved promising was to create a loop-free causal map of a policy system. Such a map should begin (let us say on the left side of the board) with the policy actions being proposed to solve the problem and proceed to demonstrate the direct causal chain that connects these actions to various components of the goal hierarchy. Telling the story of this causal chain created the "feedback-free policy insight." This policy insight told a story of how a proposed set of actions would further overall system goals. Quite often, when the feedback loops driving the system were added, the policy story changed in important ways. The chunk of dynamic insight was most easily articulated by studying how the feedback-free and feedback-rich policy stories differed. We are not yet certain if this heuristic for generating high level "chunks" of dynamic insight will generalize. More work is needed.

Part III: Pedagogical Materials

In the process of teaching the spring 1997 course, a number of materials and readings were used "off the shelf" and a number of new materials were developed specifically for use in this course. Materials used in and developed for the course included the usual range of lecture slides and notes, cases, simulation games and labs, readings, and of course a syllabus to pull all of the pieces together. Two cases and one potential learning environment were used on an experimental basis in the class and they are described briefly below.

The *State Aid Finance Case Study* was based on the simulation work of Richardson and Lamitie (1989), Andersen (1983), and Andersen, Chen and Nguyen (1981), among others. It posed the dilemma of using direct state aid to equalize per pupil expenditures and challenged students to think through the feedback effects of local school district responses to changes in state policy. This case had built into it a "shifting the burden to the intervenor" system archetype.

The GORA case (Andersen & Richardson, undated) was based on the work of Mojtahedzadeh and Andersen (1996) and looked at a "growth with underinvestment" system archetype in the

public sector. Agency managers were facing a virtually infinite demand for their services and were becoming overwhelmed by free or under-priced demand for public services. Students were challenged to find alternate ways of providing the resource base for this government service.

Finally, the class worked with a simulation model of Welfare Reform in Cortland County (a summary of that work is presented in this volume) and a future offering of the course may be able to use a gaming version of that simulation model.

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