

## Teamwork in group model building

George P. Richardson and David F. Andersen

Ongoing research at the Rockefeller College of Public Affairs and Policy is focusing on strategies for efficient and effective model building in groups. The intent is to involve a relatively large client group in the business of model formulation. Recent projects have explored strategies for accelerated group model building in the context of three public policy problem areas: foster care in New York State, Medicaid costs in the state of Vermont, and homelessness policy initiatives in New York City.

Five roles appear to be essential to support effective group model building: the facilitator, the modeler/reflector, the process coach, the recorder, and the gatekeeper. This article identifies the five roles, briefly discusses the problem areas, sketches the design of the group model-building efforts, and hypothesizes principles and strategies to guide future group model building.

Ongoing research at the Rockefeller College of Public Affairs and Policy is focusing on strategies for efficient and effective model building in groups. The work is related to efforts by Richmond (1987), Vennix (1990), and Morecroft et al. (1991), and grows out of more than 15 years of research on computer-aided, facilitated meetings (e.g., Milter and Rohrbaugh 1985; Phillips 1988; Carper and Bresnick 1989; Rohrbaugh 1992; Vari and Vecsenyi 1992; see Vennix et al. 1992 for further references). Group model building, as we intend the phrase, signals the intent to involve a relatively large client group in the business of model formulation, not just conceptualization. The goals are a wider resource base for insightful model structure, extended group ownership of the formal model and its implications, and acceleration of the process of model building for group decision support. However, the pitfalls generated by group processes and the modeling process are formidable.

It appears that no fewer than five roles or functions are essential to support effective group model building. We call the five roles the facilitator, the modeler/reflector, the process coach, the recorder, and the gatekeeper. Many of us have tried to make do with one or two individuals handling these five roles (usually implicitly), but our experiences with large modeling groups struggling with weighty problems that involve diffuse knowledge suggest the roles are often best handled by separate individuals.

Ideas about the importance of these roles grew out of the group process literature,<sup>1</sup> the system dynamics literature,<sup>2</sup> and experiences of the Decision Tectronics Group at the University at Albany,<sup>3</sup> including work done in 1987 and 1988 for the New York State Insurance Department on medical malpractice insurance regulatory policy.<sup>4</sup> Recent projects at the Rockefeller College have explored strategies for accelerated group model building involving these five roles. The explorations have been carried out in the context of three public policy problem areas: the burgeoning cost and caseload of foster care in New York State, recent unexplained increases in Medicaid costs in the state of Vermont, and homelessness policy initiatives in New York City.

### The five roles

#### *Initial modeling motivation*

In work done for the New York State Insurance Department in 1987 and 1988,

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one of the authors (Richardson) experienced some difficulties working with a five-member model reference group in preparation for two two-day decision conferences on malpractice insurance regulatory policy. Reflecting on those difficulties, we hypothesized that they stemmed from the multiple roles the modeler was trying to fill. The modeling tasks involved drawing out information from the reference group about the structure and behavior of the problem, formulating that information in a model, presenting and explaining the model formulation back to the reference group, eliciting their reactions for model corrections and refinements, and carrying out the necessary revisions and extensions. All the while, the modeler had to function simultaneously as an enlightened group process coordinator, knowledge elicitor, group facilitator, and system dynamics educator.

The modeler had the advantage of carrying out these meetings in the context of the work of the Decision Tectronics Group. As a result, he knew of the importance of a second person who could focus on recording information so that the modeler/consultant could be saved that task, but nonetheless the rest was too much. The modeler/consultant found he could not focus on all the necessary group tasks at the same time: His modeler/explainer/educator roles became confused with, and sometimes even contradicted, his roles as knowledge elicitor and group process facilitator. We modelers might have missed or ignored the confusions, as we and other modelers have in the past, but DTG decided to conduct our next meeting with an experienced group facilitator, and a much more powerful way of handling group model-building discussions was revealed.

#### *Five roles in group model building*

This more powerful way involves explicitly separating the distinct roles involved in the group model-building process. Following further experiments with group model building, which are described in this article, we have identified what we believe are five essential roles. The people who fill these roles form the basis for an effective group modeling support team:

**FACILITATOR.** Functioning as group facilitator and knowledge elicitor, this person pays constant attention to group process, the roles of individuals in the group, and the business of drawing out knowledge and insights from the group. This role is the most visible of the five roles as the facilitator constantly works with the group to further the model-building effort.

**MODELER/REFLECTOR.** This person focuses not at all on group process but rather on the model that is being explicitly (and sometimes implicitly) formulated by

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the facilitator and the group. The modeler/reflector serves both the facilitator and the group. He thinks and sketches independently, reflects information back to the group, restructures formulations, exposes unstated assumptions that need to be explicit, and in general serves to crystallize important aspects of structure and behavior. Both the facilitator and the modeler/reflector in our experiments have been experienced system dynamics modelers.

PROCESS COACH. This person focuses not at all on content but rather on the dynamics of individuals and subgroups within the group. It has been both useful and annoying that our process coach is not a system dynamics modeler; such a person can observe unwanted effects of jargon in word and icon missed by people closer to the field. The process coach in our experiments has tended to serve the facilitator; his efforts have been largely invisible to the client group.

RECORDER. Writing down or sketching the important parts of the group proceedings is the task of this person. Together with the notes of the modeler/reflector and the transparencies or notes of the facilitator, the notes and drawings made by the recorder should allow a reconstruction of the thinking of the group. This person must be experienced enough as a modeler to know what to record and what to ignore.

GATEKEEPER. This role is filled by a person within, or related to, the client group who carries internal responsibility for the project, usually initiates it, helps frame the problem, identifies the appropriate participants, works with the modeling support team to structure the sessions, and participates as a member of the group. Aware of system dynamics literature and practice but not necessarily a modeler, the gatekeeper is an advocate in two directions: within the client organization she speaks for the modeling process, and within the modeling support team she speaks for the client group and the problem. The locus of the gatekeeper in the client organization will significantly influence the process and the results.

We hypothesize that some of these five roles may be combined, or distributed among the consultants and the clients in a group model-building project, but that all five roles or functions must be present for effective group support. We further hypothesize that group modeling efforts can be significantly accelerated by explicitly recognizing the five roles and deliberately assigning them to different skilled practitioners. The following cases illustrate the use of the five roles and begin a process of testing their value in group model building.

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## The cases

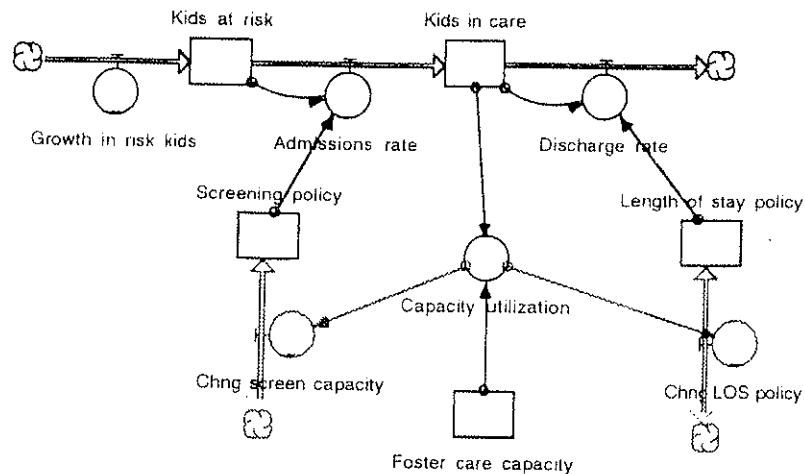
### *Foster care*

In 1990 system dynamics practitioners at the Rockefeller College were approached by the Department of Social Services (DSS) in New York State to explore the potential of simulation modeling to aid understanding of the structure and dynamics of foster care populations. Traditionally a small and placid part of the New York State budget, foster care began to grow dramatically after 1985, owing, it is thought, to the emergence of the crack cocaine epidemic. Nationally known for the creation and analysis of extremely detailed databases of foster care in several states, our contact at DSS had two interests: contributing to solutions of the problems generated by rapid growth in the need for foster care in New York City and elsewhere, and experimenting with nonlinear simulation modeling to reveal structural foundations for complex dynamics. Some very detailed modeling work, showing the ability to match the DSS data, was pursued at the Rockefeller College to the point of reports and recommendations to the Commissioner of Social Services (Wulczyn et al. 1990a; 1990b).

To further the effort, we became interested in exploring an accelerated group modeling effort that had as its core idea the separation of three primary roles that had seemed significant in our earlier medical malpractice work: a group facilitator/elicitor, a modeler, and a recorder. Our contact at DSS (whom we later realized performed the crucial gatekeeper role) assembled a group of experts in foster care willing to spend two days experimenting with a simulation modeling approach largely unfamiliar to them.

The two-day workshop began with sketching a simple concept model of the foster care system (Fig. 1). The concept model served three purposes. First, it was the medium for teaching the stock, flow, and causal-link icons to be used throughout the workshop. Second, it was used to show that there are links between structure and dynamic behavior. The model was simulated three times, showing the effects of successively closing negative feedback loops (indicated by the grey structures shown in Figure 1), striving to control the foster care caseload. The first run, without either of the controlling loops, showed unconstrained exponential growth in both child populations (labeled in the workshop "kids at risk" and "kids in care," as in Figure 2). Figure 2 shows the dynamics of the second run, in which the screening policy loop was activated, reducing the inflow to "kids in care" when the stock begins to exceed the care capacity. Third, and perhaps most important, the concept model served to initiate discussion about the structure and behavior of the real system. The model looked enough like the foster care system to be immediately familiar to the participants, but it was agonizingly inadequate, and discussion of how to improve it began immediately.<sup>5</sup>

Fig. 1. Foster care concept model, initially shown in the foster care group modeling workshop with constants for screening and length of stay. The negative loops indicated by the gray structures were added, one after the other, bringing the case-load under control, with various adverse consequences.

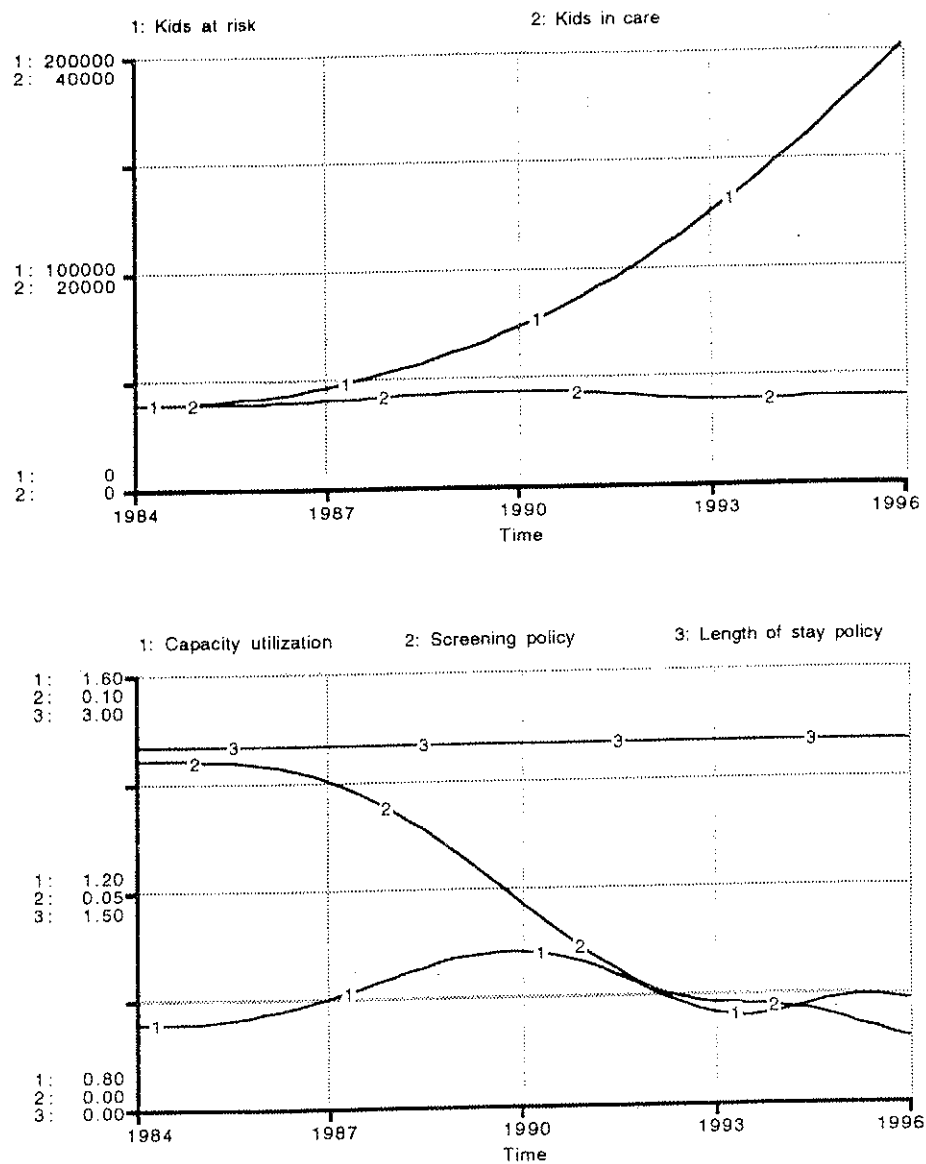


The facilitator/elicitor then took over, and the group began discussing dynamics and the stocks and flows of children in the foster care system. Large white boards were used to sketch diagrams; standard white flip charts stored important ideas; notes were kept on a computer by a recorder; and the modeler/reflector, as refiner of model structure, sketched and formulated and reformulated on paper. Periodically the modeler/reflector intervened and worked with the group directly to clarify parts of the discussion, add a modeling or system insight, or emphasize an important point.

The group evolved the view of stocks and flows of children in the foster care system shown in Figure 3. By dinnertime on the first day of the workshop, the rudiments of a model formulation involving four sectors had been crafted by the group and the modeling support team: child stocks and flows, child protective services staff and caseworkers, care capacities, and workload effects. The modeler/reflector spent the evening after dinner translating the model into STELLA<sup>6</sup> while the facilitator worked with the group to assign values to parameters, initial values, and initial flows. The parameter elicitation exercise was surprisingly crucial, not only providing input to the modeling effort but revealing areas of uncertainty, disagreement, and actual ignorance among these experts on foster care, which pointed toward the need for further work. The next morning, after a session to review the definition of the problems being addressed, the model was simulated for the group.

The workshop was considered a great success by all the participants, with the modeling team flushed with enthusiasm about developing a significant model with the active participation of 12 experts in under two days. Yet for a year little obvious follow-up work resulted. The individual whom we called

Fig. 2. Foster care concept model  
—closing the screening policy loop.



the gatekeeper worked within his agency on foster care database development and the planning of a major New York State initiative known as the Home Builders project. A year later the modeling support team worked with a group of foster care agency heads in New York City in a similar but much abbreviated fashion to set a base for understandings about the implementation

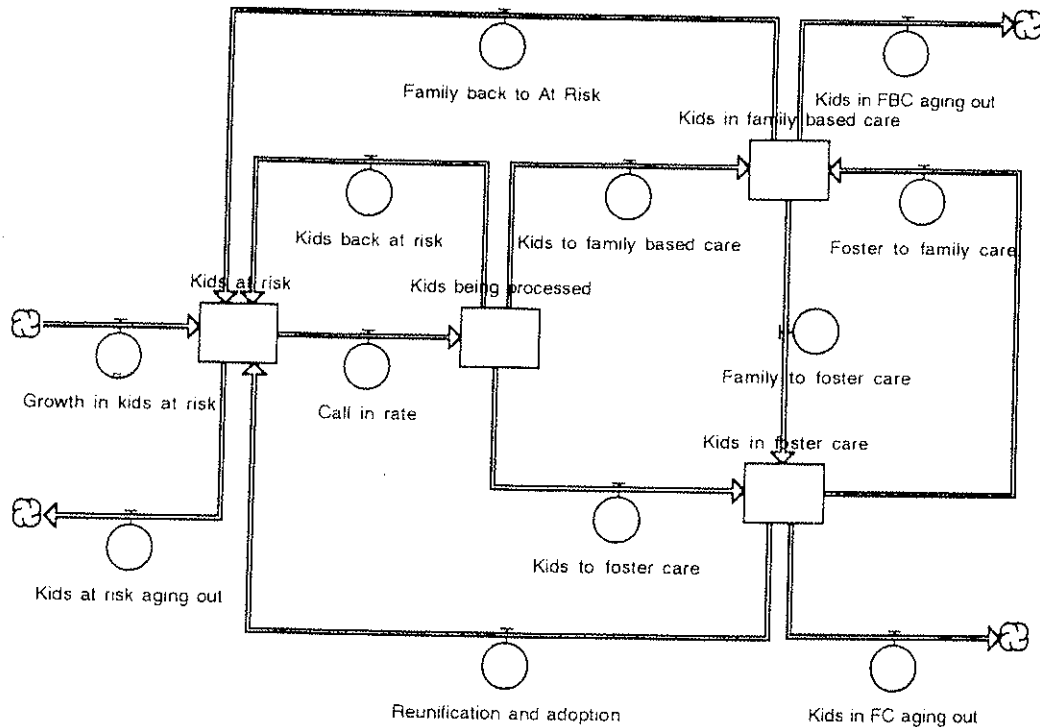


Fig. 3. Stock-and-flow diagram of foster care populations conceptualized in the foster care group modeling workshop. The model formulated around this structure, parametrized, and simulated during the workshop contained more than 80 equations (ten levels) organized into four sectors.

of Home Builders. This experimental program will alter funding mechanisms in an effort to focus resources on aftercare, an idea that was supported by model-based analyses from the foster care modeling work.

#### *Medicaid in Vermont*

Prior to 1990, Medicaid costs in Vermont had been reasonably predictable. Although rising, costs were sufficiently well-behaved to allow the department's traditional procedures to anticipate and budget for next year's costs well. But in 1990, Vermont's Department of Social Welfare, the state's designated Medicaid agency, part of its Agency of Human Services, was forced to go back to the Legislature several times in the space of six months to request budget adjustments to cover dramatic unanticipated increases in costs. Concern about the traditional approaches led to the opportunity to try to introduce systems thinking and simulation into the workings of the Agency of Human Services. The new head of the agency approached a colleague who had been involved extensively since 1982 using system dynamics modeling and simulation to

forecast Vermont's electrical energy demand and supply. The agency head wanted to approach the Medicaid cost problem in particular, and Vermont human service planning in general, more systematically, although he had a diffuse notion of what that meant, more in the vein of the MIS/program budgeting approach (e.g., Churchman 1968) than system dynamics. The Vermont energy modeler held several small group sessions with agency management, presenting STELLA and discussing the systems approach.

Vermont then contacted system dynamics practitioners at the Rockefeller College to see if they knew of work on Medicaid in the system dynamics literature. Fresh from the foster care work, we were interested in trying again to engage a large group in the modeling process, so a series of group model-building workshops were set up as part of a project to model the Medicaid cost problem. The Vermont energy modeler became the gatekeeper on this project and indeed by his activities helped to reveal the importance and dimensions of this role in group model building.

The Medicaid problem is a significant one and had high visibility in the Vermont Agency of Human Services, so there were a number of groups of players who needed to be involved. Our Vermont contact identified the following:

- *Stakeholders.* Agency and department heads with significant responsibility for the Medicaid program or financial management in the state, members of the Governor's staff, and an invited outsider from the National Governors' Association.
- *Experts.* A group of people within the Vermont Agency of Human Services (including some stakeholders) who are most knowledgeable about the Medicaid system in Vermont, together with some members of key health care policy groups outside the agency.
- *The core modeling group.* A small group of people who would directly support the model-building efforts with data and analyses and who could be expected to carry on the simulation work after the initial group work was completed.

He assembled lists of people in these categories, developed their interest, taught many of them something of the system dynamics approach, and enrolled them in the project.

With its visibility and potential political importance, the project became larger than the experimental work with the foster care modeling group. The modeling team was reluctant to enter two days of workshops with all three groups, including the important stakeholders, without a warm-up group model-building workshop or rehearsal. So we carried out a series of group model-building workshops in which the first and third involved the experts and core group in the most modeling-intensive parts of the project: May 28,



1991—experts and core group modeling workshop; June 27–28—stakeholders, experts, and core group modeling workshop; July 16—experts and core group model revision workshop. The second workshop, involving all the participants in the project, was staffed by a full group model-building team consisting of facilitator/elicitor (Andersen), modeler/reflector (Richardson), recorder (an advanced doctoral student), and process coach (a colleague expert in group process and decision conferencing). The gatekeeper was a participant in all three workshops. The first and third workshops, with the experts and core group, were handled by the same team without the process coach; the modeler/reflector and gatekeeper contributed some group process observations and advice to the facilitator during the breaks.

As in the foster care workshop, the May and June Vermont Medicaid workshops both began with a concept model, diagrammed in Figure 4. The base run of this concept model (Fig. 5) is driven by small increases in unemployment, federally mandated eligibility for Medicaid, and annual cost per user. The resulting sharp rise in Vermont Medicaid expenditures exhibited by the model reflected the recent Vermont experience.

The evident adequacies and inadequacies of the concept model immediately stimulated discussion, which led in the workshop to the model diagrammed in Figure 6. The obvious malleability of the models, and their partial fit to the mental models of the participants, led to a laundry list of concepts and variables the group wished to see incorporated into a full model useful for forecasting and policy.

Fig. 4. Initial concept model for Vermont Medicaid group model-building workshops.

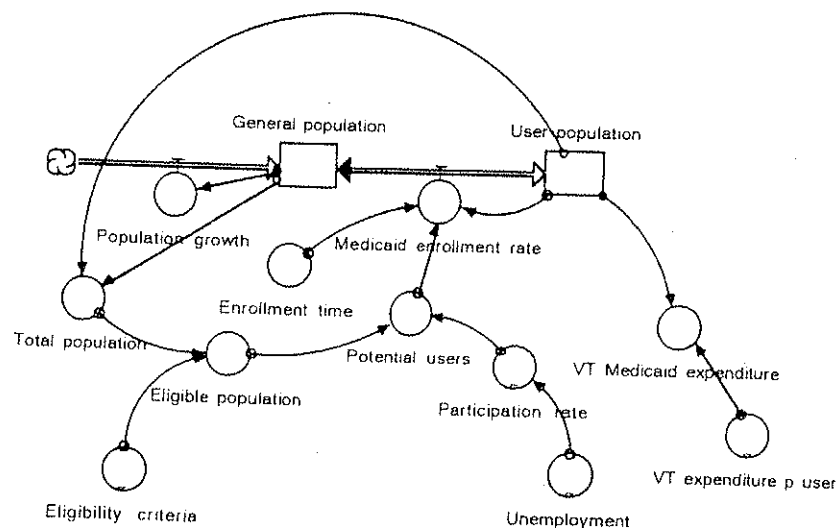
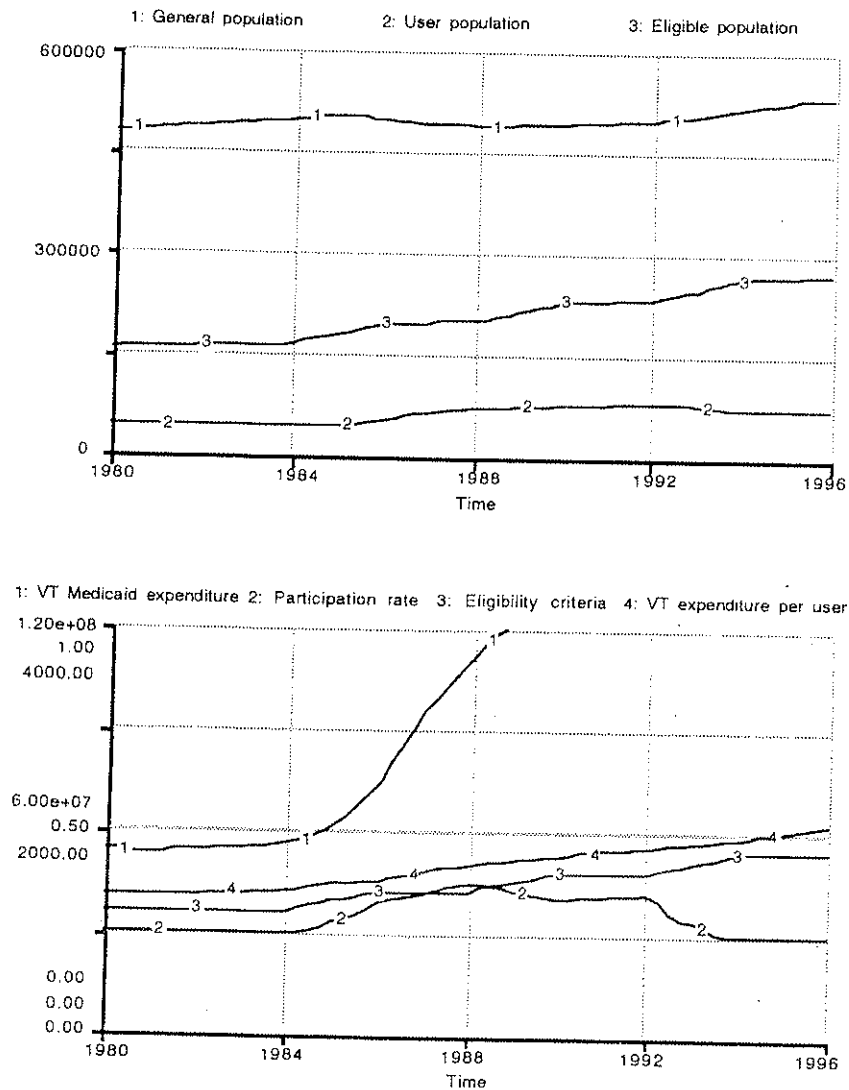


Fig. 5. Vermont Medicaid concept model, with small increases in mandated eligibility, unemployment, and annual expenditures per user.



The second of the three workshops was attended by all three groups: stakeholders, experts, and core group. The interaction proceeded as in the previous group model-building workshops, but a working model did not result. Modeling proceeded after the workshop in the more traditional way (behind the scenes), and the third workshop used the five-role scheme (but without the process

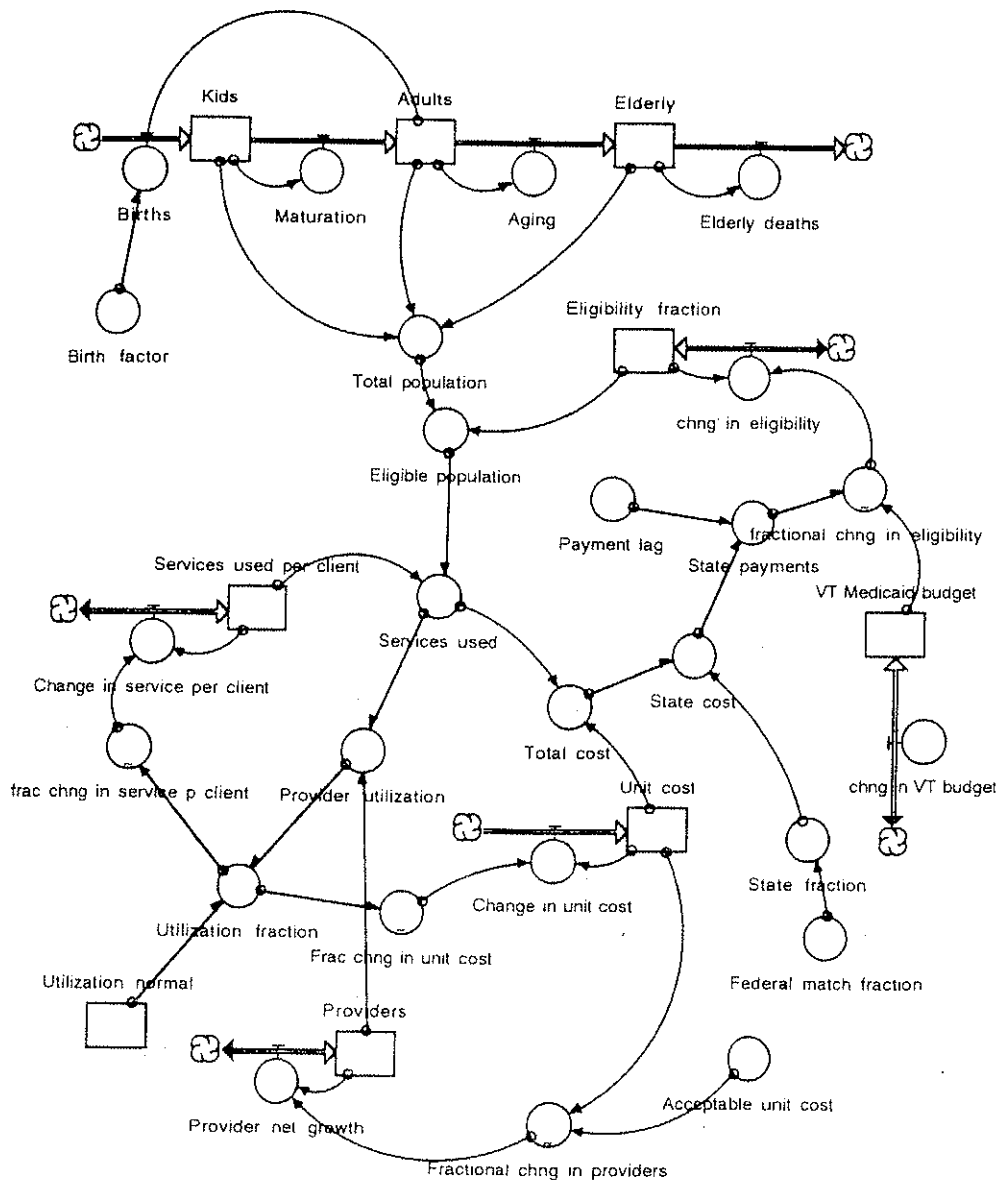


Fig. 6. Simple Vermont Medicaid model developed during the first group modeling workshop. The model was formulated by the modeler/reflector while listening to the first hour-and-a-half of facilitated group discussion presented back to the group, composed in STELLA during the break and lunch, and simulated for the group.

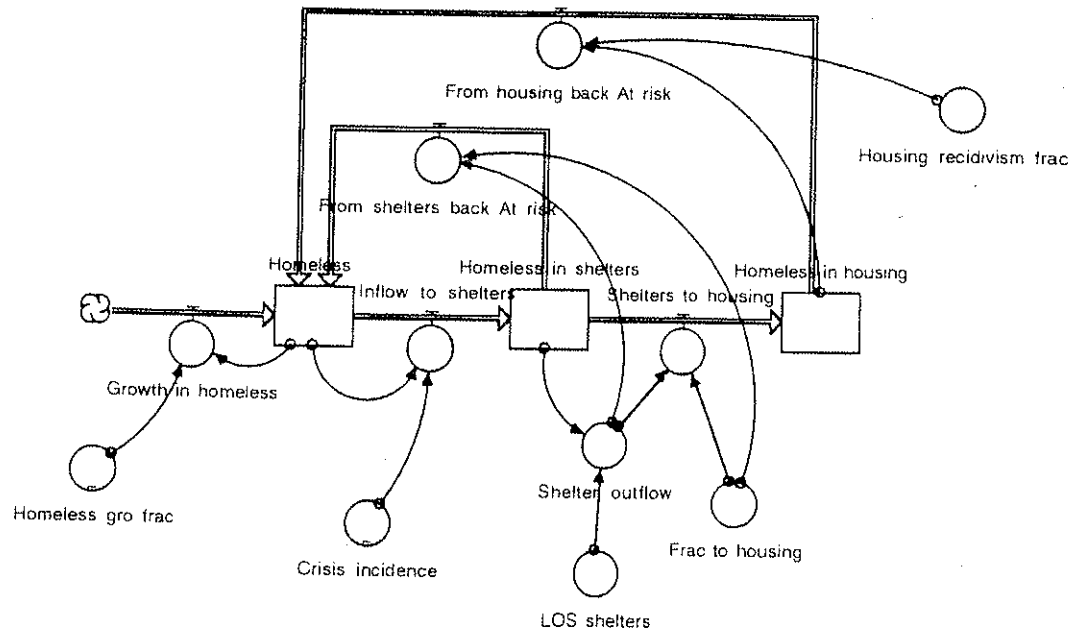


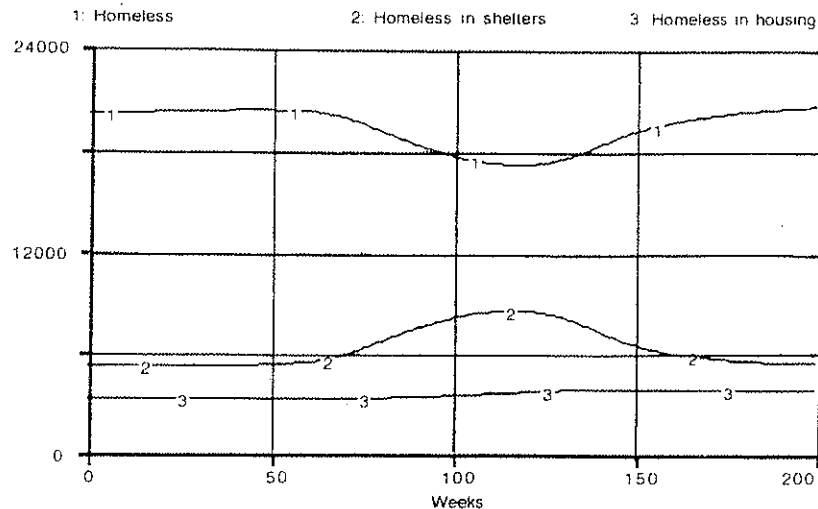
Fig. 7. Second concept model in the New York City workshop on homelessness, with recidivism flows added. We exposed the friendly algebra that separates the shelter outflow into the flow to housing and the flow back at risk.

coach) to review, critique, and revise the model.<sup>7</sup> In this last workshop the modeler/reflector acted not as a master modeler but more as a reflector on the group's discussion, a "contemplator" whose job was to refine and crystallize the thinking of the group. We came to understand that the role of the modeler/reflector is more general than that of modeler and that there is great value to having a person reflecting on the group's thinking and reflecting it back to them. The modeler/reflector can perceive subtleties the facilitator might miss, can identify linkages and systems insights that emerge only from reflection, and can punctuate the discussion with points of important emphasis.

#### *Homelessness in New York City*

Our most recent experience with these ideas in a group model-building workshop occurred at the invitation of a team of modelers in the Operations Research Unit of the New York City Office of Management and Budget (OMB). The team had experimented with an iThink model intended to help forecast needs for resources to deal with the growing homelessness problem in the city, and they sought support in carrying out a two-day model refinement workshop involving homelessness service providers and policymakers.

Fig. 8. Dynamics of the concept model in Figure 7 disturbed by a short-term rise in the crisis incidence fraction.



The workshop was unusual in that many of the participants had seen elements of OMB's model. It began with two concept models. The first was a simple aging chain of three levels representing homeless families, homeless families in shelters, and homeless families in housing. The second, shown in Figure 7, built on the first and added flows from the sheltered and housed populations back into homelessness (recidivism). Although we had prepared the second model in advance, these recidivist flows were elicited from the participants to involve them in the process of model conceptualization, formulation, and revision. As in the group model-building sessions described earlier, the models were simulated and altered a bit, to emphasize the roles of formal models in understanding structure and dynamics, and to emphasize the malleability of the formal model. Here the "crisis incidence" fraction (a table function of time) was increased for a short period to simulate a bulge in the flow of homeless families into shelters. The resulting unsurprising population dynamics are shown in Figure 8.

At this point in the workshop, the OMB team took over and presented the structure and behavior of their model. It was far more detailed and accurate than the concept model in its disaggregation of families in various stages of the homelessness service system. Most of the morning of the first day was spent understanding the structure and dynamics of this complex view of the stocks and flows of homeless families in the current and proposed New York City homelessness service system. Yet it too lacked a crucial set of policy variables—the capacities of the system (people and beds) to handle the homeless family caseload.

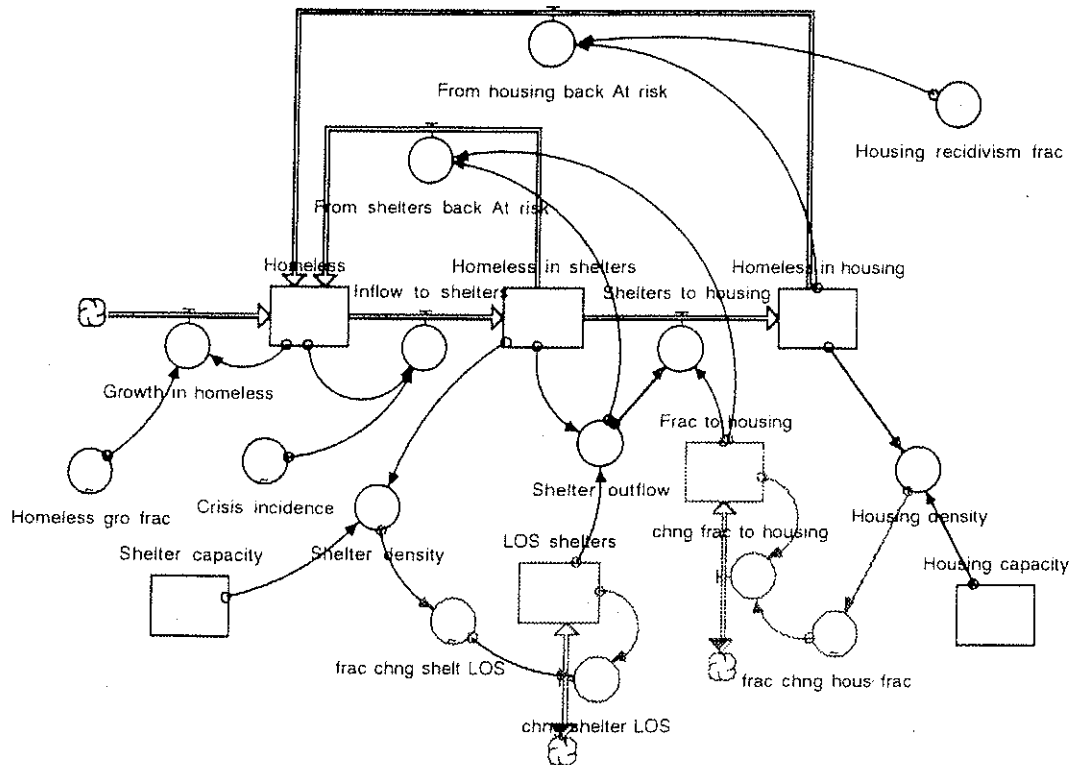


Fig. 9. The concept model of Figure 7, showing a series of additions. First, the shelter and housing density ratios were added and the model simulated. The pressures emanating from these densities (shown in gray) were then elicited from the group, formulated with them, and simulated.

By prior agreement with the OMB team, we began the afternoon session with another addition to the simple concept model—shelter capacity and housing capacity, both thought of as a number of families that could be accommodated. The capacities were linked to the families in the system simply by ratios, the shelter density and the housing density (see Figure 9, ignoring the gray elements for the moment). We showed the group the previous simulation run (Fig. 8) and displayed the graphs of the density ratios, which rose dramatically beyond acceptable or sustainable levels. We then asked the group what pressures these densities would generate if they approached or exceeded 1. That question, repeated in many contexts as the workshop continued, proved incredibly productive, for it leads naturally to the closing of feedback loops and the subsequent identification of circular causal processes important in the system.

Here the group suggested that rising population densities would shorten the average length of stay in shelters (to speed families out and make room for the

growing inflow) and would decrease the fraction of the shelter outflow that could move into permanent housing (because there would be no room in housing for the increased flow). We sketched the structures shown in Figure 9 on a white board, motivated the necessary equation formulations, and then simulated the model (which we had prepared in advance). Figure 10 shows the rather complex dynamics that result from the interactions of these stock-and-flow feedback structures. They had the desired effect: without understanding the dynamics in detail or linking them to experience in the homeless care system, the group grasped the essential idea that system behavior is a consequence of system structure.

The remainder of the first day and all of the second day were devoted to exploring in detail the capacities in the system judged by the group to be crucial for the policy modeling effort. Staff and bed capacities in all sectors of the detailed OMB model were identified, diagrammed one at a time, and linked to the rest of the sector. Figure 11 shows a typical diagram sketched in front of the group in response to suggestions of the group, here capturing homeless families in the income support unit and the assessment process. The figure shows the beginnings of a number of feedback loops stimulated by considering the load or density ratios of families in these units relative to staff or bed capacities.<sup>8</sup> This particular diagram is of interest because it shows several contributions of members of the group that had not emerged earlier. Guided by the facilitator, participants noted that when the density of families in assessment becomes too great, entry to assessment is shut down, but families can't stay in the income support unit (an office that provides funds to families in crisis), so there must be a potential flow into Tier II housing that bypasses the assessment process. It was also during elicitation and discussion of this diagram that participants noted that the promise or potential of permanent housing has the effect of increasing the entrance of families into the housing support system—the links at the bottom of the figure were added to reflect what participants were saying, with all knowing that they connected to elements of the system not shown in the diagram.

The generic density or load structure representing capacity utilization has become for us an element of a productive group model-building script, which we can call upon as appropriate in other settings. It generates feedback loops in a language participants are comfortable with, their natural one-way causal language. Feedback loops emerge out of considering the effects of densities, vacancy rates, and loads. We see great potential in the modeling community for the accumulation and sharing of such scripts.

Four separate roles were clearly in evidence in this two-day group model-building and model refinement workshop: the facilitator/elicitor, the modeler/reflector, the recorder, and the gatekeeper. The first two roles were handled by

Fig. 10. Dynamics of the elaborated homelessness concept model in Figure 9 (including the gray elements).

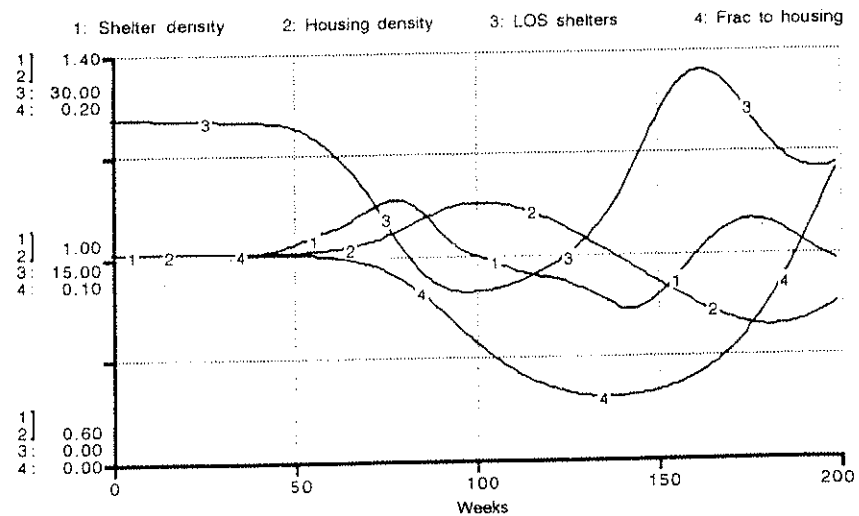
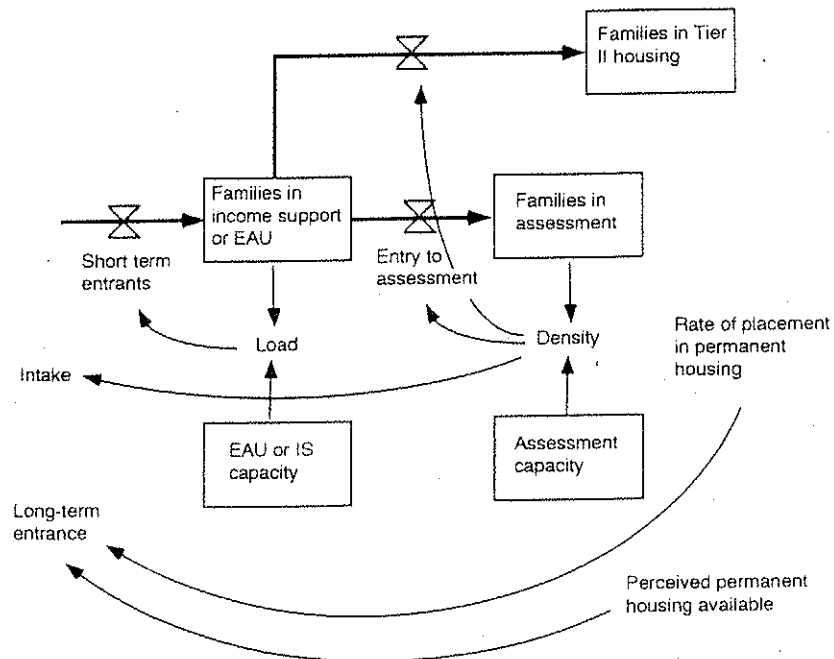


Fig. 11. A typical diagram from the New York City homelessness group modeling workshop, showing the use of density ratios or vacancies to elicit from the group system pressures that close feedback loops.





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Andersen and Richardson, respectively, with some switching for short periods. The role of recorder was handled by the two members of the OMB modeling team who also planned the workshop with us. The gatekeeper was the director of the Operations Research Unit who had invited us, assembled the group, and taken an active part in the proceedings, more as part of the modeling team than as a participant expert on homelessness. We were missing only a process coach. Sensitive to that need, we and the modeling team all shared the duties of the role of process coach throughout the two days, observing as best we could the group dynamics at the same time we handled our other tasks.

### **Reflections on the group model-building process and the five roles**

#### *Perceived value of recognizing the five roles*

The complexities of problem conceptualization, model formulation, and group process suggest that separating the roles of facilitator/elicitor and model crystallizer in large groups greatly facilitates model development. Our experiments have involved from three to five actors taking the five roles. Many system dynamics practitioners have pursued group work by themselves, commonly aided by a person within the group fulfilling the role we have identified as the gatekeeper. In such one-person interventions, the system dynamics practitioner functions at various times, or simultaneously, as group facilitator, knowledge elicitor, educator, modeler, and recording secretary. At a minimum, our experiences and the literature they are based upon suggest that recognizing these multiple and conflicting roles is essential for smooth group process and effective model-based group strategy support.

But it is very likely that the minimum is not enough. To work effectively and efficiently with large client groups and to accelerate group modeling to the point of conceptualizing, formulating, and simulating a reasonably complex model in two days almost certainly requires a team of several people, each paying attention to separate aspects of the process. Even for more traditional modeling projects in which models are built in the weeks between client group meetings, the more powerful minimum is not one person enlightened by perceiving several essential roles but at least two people in a group modeling team, one focusing on group facilitation, knowledge elicitation, and initial drafts of structure, and the other focusing on the problem, the system being conceptualized, real-time refinements of structure, and emerging insights. We suspect that the best group modeling work in system dynamics in the past has followed at least this minimal team structure, with members of modeling teams implicitly

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moving into and out of the unrecognized roles we are now identifying. Just as a fluent basketball team plays better when positions are assigned, we suspect that assigning roles in group modeling, even fluid ones, will significantly improve the play.

### *Skills*

In our experiments the facilitator/elicitor and the modeler/reflector have been experienced system dynamics modelers who also have considerable experience and interest in working with groups. The range of skills possessed by such people is difficult to list, and we acknowledge we do not know what specific skills are really crucial.

### *Scripts*

Some of the more obvious skills fall into the category of scripts—planned and rehearsed routines for accomplishing subgoals in the course of a group model-building workshop. The system dynamics literature containing aspects of such scripts is small but worth perusing (e.g., Stenberg 1980; Wolstenholme and Coyle 1983; Richmond 1987; Vennix et al. 1990; Vennix 1990; EJOR 1992; Saeed 1992; Lane 1993; 1994). We view the accumulation and sharing of group model-building scripts as a high priority for the field. Widespread experience with a growing collection of group model-building scripts would move in the direction of an explicit and increasingly reliable set of group model-building processes that modelers can acquire, practice, and extend. (See Andersen and Richardson 1994 for the beginnings of such an accumulation of group model-building scripts.)

### *Concept models*

A particular set of skills and attitudes apply to concept models, the special-purpose models with which we have begun our group modeling-building workshops. Concept models are crafted specifically to introduce the stock, flow, and causal-link icons to be used throughout the workshop, to demonstrate that there are connections between feedback structure and dynamic behavior, and to initiate discussion about the structure and behavior of the real system. The understanding that emerges from these simple concept models is the only knowledge of system dynamics we require of the group at the outset. We devote no more than 20–30 minutes to these in a workshop, so that we can get the group involved in the modeling process as soon as possible. Because of these sharply defined pedagogical purposes and our desire that the

models should essentially "teach themselves," we find concept models tricky to build.

The principles we have evolved for formulating concept models include the following:

- Use two, or at most three, levels for the first concept model.
- Use algebra you would be willing to show to the group, even if that requires weak formulations (e.g., the gray rates in Figure 1 are formulated as open-loop integrations, and two of the time series inputs in Figure 4 should be endogenous rather than exogenous).<sup>9</sup>
- Draw the structure by hand, explaining the icons and structural intent, before showing the computer model.
- Begin with a model that is clearly unrealistic in some obvious structural way, so the group can develop it (e.g., the first concept model in the homelessness workshop contained no recidivism).
- Name variables conceptually, not mathematically (e.g., in Figure 1 we named the fraction of kids at risk admitted per month *the screening policy*, guessing that this term would link well with the group's ways of thinking and would focus on the real system).
- Add structure that the group would suggest but prepare the additions in advance.
- Add structure that makes a dramatic difference in model behavior, usually by adding a feedback structure that contains realistic stocks or delays (the gray structures in Figures 1 and 9 are typical).
- Show at least two, and at most three, versions of the concept model, with the final version showing the most interesting, most realistic, or most surprising dynamics.

The goal of a concise series of two or three concept models is a participant group eager to get into the process of model building, assured that the formal models they build will be flexible tools for thinking realistically about system structure and dynamics, and that they are in control.

#### *Dos and don'ts*

A subset of the group model-building scripts the modeling community should develop and share are dos and don'ts—quickly stated activities or attitudes to definitely follow or definitely avoid. We have operated on such guidelines as "Get the group talking as soon as possible," "Be scrupulously consistent in diagrammatic notation from one diagram to the next, and from hand-drawn diagrams to computer displays," "Script the workshop in detail, but treat the script as a framework for productive improvisation," "Pay scrupulous attention

to the geometry of seating, white boards, computers, projection screens, and the like," and so on. Some of our dos and don'ts come from the group process literature, some from intuition, some from the simple necessity of needing consistency from one group model-building effort to the next, and some no doubt from our idiosyncratic preferences. We are convinced, however, that there are better and worse ways to go about building in groups, and we encourage others to contribute to the accumulation and testing of dos and don'ts. (See Andersen and Richardson 1994 for a development of these ideas.)

#### *Role conflicts*

The modeler/reflector can interfere with the flow of group process being shaped by the facilitator/elicitor. In our experiments the modeler/reflector would occasionally present to the group and discuss reflections on the group's problem definition, system conceptualization, model formulation, and policy implications. If not done with great care, moves by the modeler/reflector can derail lines of thinking being pursued by the facilitator/elicitor.

While the modeler/reflector functions as a content coach, a process coach focusing solely on intragroup interactions can be enormously beneficial in helping the facilitator maintain the group's motivation and momentum. However, both process and content coaches have to keep in mind that the facilitator/elicitor is, in a sense, on stage and vulnerable. Hearing that "the group is unravelling" or "something must be done to energize those folk over there" can be unnerving to the facilitator. We have chosen the word *coach* advisedly—a coach does more than diagnose problems; a coach suggests plays. And great coaches make their suggestions with deep knowledge of the situation in the game and all the players' strengths and weaknesses.

#### *Explainer/elicitor conflicts*

Most system dynamics group work must involve some discipline-centered teaching about the approach, along with the group-centered elicitation of knowledge about the structure and dynamics of the problem. Explaining the mysteries of system dynamics or of a particular model formulation can get in the way of uninhibited group discussion focused on the problem independent of approach or formulation. A group model-building team can err badly in two directions: teaching too much about the system dynamics approach and model formulations, and teaching too little about them. Teaching too much interferes with getting information about the group's problem. The group learns much about the approach, the modeling team hears mostly just what it taught, and the group's problem remains largely unaddressed. Teaching too little can lead

to badly targeted group discussions that do not help the development of a dynamic feedback view of the problem.

In our work on Vermont Medicaid, the group worked extremely well together but was reluctant to go beyond numerical data to assert causal mechanisms in the intricate doctor/patient/reimbursement Medicaid system. The modeling team pressed for some causal feedback views but did not force an endogenous dynamic feedback view. In the end, the team was left with few insights about the causal structure of critical parts of the system. The further modeling work that followed, undertaken by the Rockefeller College team and the Vermont core group, has been strong on time-series data but weak on feedback structure and insight. The Vermont model-based group work might be faulted for trying to be too responsive to the group, and for failing to do a good job presenting and motivating the system dynamics approach.<sup>10</sup>

#### *The client group*

It is clear that the success of a group model-building effort depends to some degree on the thoughts and agendas the client group itself brings to the workshop. (There is even a question about what success in group decision support means and how it can be assessed; see McCartt and Rohrbaugh 1989.) There are undoubtedly interactions between the nature of the problem, the culture of the client organization, and the individual personalities in the room, which all influence the group model-building process. The size of the group is important—we try to work with a group of about 12 but have (reluctantly) worked with groups as large as 25. Support of the undertaking from the leadership in the organization is crucial. We strive to ensure attendance of such people throughout the workshop and ask them to provide the opening and closing statements that shape the purpose and direction of the undertaking in the wider organization. Breadth of knowledge and diversity of points of view in the group seem crucial to the success of a model-building effort, but it is reasonable to guess that too much breadth and diversity in the room could create conflicts that could greatly inhibit the process. Facilitation can help unaligned groups function better, but in extreme situations the modeling team can become the lightning rod for an unhappy group's frustrations. One might wonder whether these issues are more or less extreme in public sector interventions or private sector efforts. We have experimented only in public sector situations and can only assume that experiences in the private sector would show the same themes, scripts, problems, and potential.

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*The uniquely gifted practitioner hypothesis*

We believe that group model building is a mix of skills and sensitivities that any modeler can master, but there remains the question of whether some practitioners have implicit, innate capabilities that enable them to be better at it than others. That is, can anyone do this, or is it the domain of "uniquely gifted" practitioners or teams? Modelers must avoid falling into the trap of this assumption. However one thinks about the question, we believe that the proper course for system dynamics practitioners is to take the "uniquely gifted practitioner" hypothesis as the null hypothesis and conduct fieldwide practitioner experiments designed to give the field a good chance of rejecting this self-limiting premise. Second-year students should practice the arts of group model building in courses. Conferences should hold fishbowl exercises in which experienced group model builders demonstrate their approaches with a subset of the folk attending. Experienced modelers should try their hand at it, aided and abetted by appropriate group model-building teams.

Team-facilitated group model building has the potential to speed the modeling process, to allow a larger client resource base for insightful model structure, to extend group ownership of the formal model, and to increase the spread of model-based understanding in the client organization. Acknowledging the preliminary nature of such group model-building efforts, we are nonetheless convinced that an enlightened ability to support groups in rapid and effective model-based investigations is an essential component of the tool kit of all professional system dynamics practitioners.

**Notes**

1. The earliest group process literature contains descriptions of numerous leadership roles that must be assumed in order for groups to be effective (Benne and Sheats 1948). Recent developments in the definition of facilitator roles have helped to clarify how group leadership can be provided by both internals and externals (Schein 1987; Kayser 1990; Friend and Hickling 1987).
2. Hints of multiple roles in modeling with groups appear in Stenberg (1980) and Vennix (1990). Roberts (1977) emphasizes rapid development of an initial model, maximum in-house participation, and the importance of the role we have called the gatekeeper. We take *gatekeeper* from the R&D literature (Allen 1970).
3. See Milter and Rohrbaugh (1988), Mumpower et al. (1988), McCartt and Rohrbaugh (1989), and Schuman and Rohrbaugh (1991).
4. See Richardson and Senge (1989) and Reagan-Cirincione et al. (1991).
5. Concept models, as we use the term, are different from the small but complete models of the sort described by Randers (1980). Instead, they are preliminary models. Because they must be very simple visually and contain nothing but

friendly algebra, they are typically rather bad first cuts at system dynamics models. Initially, they are mostly open-loop and are constructed to hide as much diagrammatic complexity as possible by eliminating parameter icons and being clever (but clear) in equation formulation. Yet they must lead the group in the direction of robust and appropriate formulations for the problem at hand. See the final section of this article for the special considerations involved in formulating concept models.

6. STELLA is a registered trademark, and iThink is a trademark, of High Performance Systems, 45 Lyme Road, Hanover, NH 03755, U.S.A.
7. Following the series of workshops, the Vermont team continued development of the modeling work, and a member of the Albany team pursued in parallel a model-based study of national health care finance policy (Ratanawijitrasin 1992), which was awarded the 1992 dissertation prize of the National Association of Schools of Public Administration and Affairs (NASPAA).
8. The group repeatedly used synonyms for this density ratio, substituting *capacity utilization*, *vacancy rate*, or *number of vacancies* to suit the discussion of the moment.
9. The slight added visual complexity of a fractional rate of change may be too distracting for some groups. We have tried it both ways without difficulty (e.g., Figures 1 and 9) but have tended intuitively to use the simpler formulation for groups who have not seen model diagrams before.
10. One might also question the extent to which the concept model driven by three time series (Fig. 4) biased the group in the main two-day workshop toward exogenous formulations. Our impressions are that the bias was already strongly in place, and we did not adequately counter it.

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