Group Modeling of IT-Based Innovations in the Public Sector

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Abstract

The system dynamics group at the Rockefeller College of the University at Albany has been developing techniques to create system dynamic models with groups of managers during the last 25 years. Building upon their tradition in decision conferencing, the group has developed a particular style that involves a facilitation team in which people plays different roles. Throughout these years of experience, the group has also developed several "scripts" to elicit knowledge from experts based on small-groups research, and well-established practices in the development of system dynamics models. This paper constitutes a detailed documentation of a relatively small-scale modeling effort that took place in early 2001, offering a "soup to nuts" description of Group Model Building at Albany. The paper describes in detail 8 of the scripts that the group has developed, offering some reflections about their advantages and limitations.

Keywords: system dynamics modeling, group model building, decision conferencing, group decision support systems, decision support systems

Introduction

Involving client groups in system dynamics model building, particularly in matters of strategy and policy presents a number of method issues (Vennix *et al.* 1994; Vennix 1999; Rouwette *et al.* 2002). Examination of these issues has increased since the first documented experiments in the late 1960's and have spanned a wide variety of group modeling techniques and conceptualizations of the group model building (GMB) process (Rouwette *et al.* 2002; Zagonel 2002). The issues examined include how to deal with individual and group constraints on information processing capability, problems of knowledge elicitation, dealing with multiple perceptions and constructions of reality, and the impacts of the facilitation process (Vennix *et al.* 1994; Vennix 1999). This paper contributes to that body of work by presenting an in-depth examination of how these issues were treated in a group modeling process combining system dynamics modeling and related group decision making methods.

Some of the issues of interest are related to group decision making as a social process, independent of the particular kinds of modeling involved. The processes of group decision making and problem solving have been the subject of considerable attention in the social sciences (Nunamaker 1989; Ackermann and Eden 1994; Poole *et al.* 2004). Actually, as pointed out by Nunamaker (1989), the history of group decision can be traced back to the ancient Greeks and Romans, who used special facilities for work in group decision-making and planning. More recently, researchers have developed a series of techniques for group decision support that have been grouped under the umbrella of the term Group Decision Support Systems (GDSS) (Quinn *et*

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al. 1985; DeSanctis and Gallupe 1987; Nunamaker 1989; Nunamaker *et al.* 1991; Ackermann and Eden 1994; Zigurs and Buckland 1998; De Reuck *et al.* 1999; Barkhi *et al.* 2002; Quaddus and Tung 2002; Gottesdiener 2003). Work with system dynamics models is closely related to one technique in particular: decision conferences. These are "computer-supported meetings in which several decision makers develop an explicit framework or structure for organizing their thinking about an important, non-routine policy or program choice" (Milter and Rohrbaugh 1985, p. 183). The technique is explicitly designed to combine the strengths of intuition and insight generated by the group with and analysis enhanced by the presence of a facilitation team (Schuman and Rohrbaugh 1991).

This technique is appropriate to a variety of modeling and analysis methods. The researchers involved in the activities reported here have been developing approaches to decision conferencing using a combination of group facilitation techniques linked to a variety of computer models developed with the group in the meeting setting (Rohrbaugh 1992). The approach has been used successfully to understand and tackle problems in areas as diverse as expert estimation and forecasting (Mumpower and Stewart 1996), bargaining and negotiation (Mumpower *et al.* 1988), resource allocation (Milter and Rohrbaugh 1985), investment decisions in information systems (Schuman and Rohrbaugh 1991; Larsen and Bloniarz 2000), and policy analysis using system dynamics (Reagan-Cirincione *et al.* 1991; Richardson *et al.* 1992; Richardson and Andersen 1995; Andersen and Richardson 1997; Kelly 1998; Rohrbaugh 2000). The group has also developed an approach to evaluate group processes (Quinn and Rohrbaugh 1983; McCartt and Rohrbaugh 1989; McCartt and Rohrbaugh 1995).

The development of system dynamics models with groups or GMB fits within this larger body of work. It does, however, present the participants with considerable task complexity, more so than in some other group decision processes. To be successful, group-based dynamic model building it relies on the knowledge generated in two main threads: decision conferencing, and system dynamics practice (Zagonel 2002). This combination presents the participants with considerable challenges and task complexity. The way the methods in the case presented here deal with these challenges can be described in terms of the framework developed by Zigurs and Buckland (1998), based on an extensive review of the decision support research. They relate the type of tasks faced in a group decision situation to the communication support, process structuring, and information processing demands according to the scheme shown in Table 1 below. The table identifies the support and facilitation technology needs in relation to five task types. The types are distinguished by outcome multiplicity, solution scheme multiplicity, conflicting interdependence, and solution scheme/outcome uncertainty. Using these criteria, the tasks presented to the participants in group system dynamics modeling are a mix of problem, decision, judgement, and fuzzy tasks. That suggests that the support technology should be high functioning on all three dimensions: communication, support, and information processing. These support and process technology requirements are reflected in the GMB approach presented here.

Table 1. Fit Profiles of Task Type and Support Technology Needs[3]

Task Type	Communication Support	Process Structuring	Information Processing
Simple	High	Low	Low
Problem	Low	Low	High
Decision	Low	High	High
Judgement	High	Low	High
Fuzzy	High	Medium	High

Process structuring requirements are addressed in this approach to GMB in part through defining roles for the facilitating team: facilitator, modeler/reflector, process coach, reflector, recorder and gatekeeper (Richardson and Andersen 1995). The roles are clustered in two groups to take responsibility for two specialized tasks: facilitation and analysis, the two pillars of decision conferencing (Rohrbaugh 1992; Vennix *et al.* 1994; Richardson and Andersen 1995; Zagonel 2002). The role definitions and behavior expectations are expressed in a series of "fairly sophisticated pieces of small group processes" called scripts (Andersen and Richardson 1997, p. 107). Scripts are conceptualized as a series of divergent or convergent activities to facilitate the cognitive processes of eliciting information, exploring courses of action, and evaluating situations (Vennix *et al.* 1994; Andersen and Richardson 1997). Scripts serve as both process structuring and communication support devices and provide for division of labor with respect to some information processing needs.

The scripts, facilitation methods, and specific modeling methods are organized and employed through a collaborative planning process that engages the modelers and client teams. This paper documents the specific procedures and products of such a GMB effort completed over a four-month period in 2001. In addition to presenting a detailed description of the process, and the products associated with the project, the paper also documents the effort needed to accomplish the objectives by both modeling and client teams. The paper extends the discussion about the use of scripts to develop system dynamic models with groups, as initiated by Andersen and Richardson (1997). The case description includes a detailed description of eight scripts that together constitute a "soup to nuts" description of the Albany GMB approach.

The case description also includes many process-related products published for the first time. These illustrate the results obtained in the case and assist other system dynamics practitioners to replicate the experience. The perceived success of the experience reported in this paper encouraged continued effort in model building that has extended into 2005. Moreover, modeling efforts have extended to a subsequent research project designed to examine the dynamics of information integration in intergovernmental projects.

[3] Adapted from Zigurs I, Buckland BK. 1998. A theory of task/technology fit and group support systems effectiveness(n1). *MIS Quarterly* **22**(3):313-334., p. 326.

Project Context

Objectives

The GMB effort described in this paper was initiated as a theory building effort in the course of a longitudinal research project on government IT innovation conducted by the Center for Technology in Government[4] (CTG). The GMB involved five staff members from the Center and a facilitation team from the system dynamics group at Albany. The main purpose of the effort was to explore the feasibility of applying system dynamics modeling to a complex interorganizational process about which only qualitative data were available. The process to be modeled was the subject of qualitative field research focused on knowledge and information sharing in interorganizational networks.[5] One research goal was to develop theory about interorganizational networks involved in IT innovation. This research had produced a large volume of observational and interview data and preliminary analyses about seven technology-related projects in government agencies.

In the course of collecting and analyzing data from this project, the researchers noted evidence suggesting important feedback effects. The feedback mechanisms appeared to influence the collaboration and knowledge sharing that are critical to interorganizational information system conceptualization, design, and deployment. These observations led to conversations with the system dynamics group at Albany. Both groups agreed that applying system dynamics methods to this process had considerable potential to yield valuable insights into collaboration research and practice. As a novel application of the methods it had potential to yield new modeling insights as well.

Project Time-line

The GMB activities took place from January to May 2001. Although the actual modeling conferences were held in April and May, initial conversations and preparation of the project started in January of the same year (see Table 2). During the first meeting in January 2001, the modeling team contacted the director of research at CTG to explore the idea of using system dynamics methods to analyze case data generated at the Center. In this way the research director started playing the gatekeeper role, as described by Richardson and Andersen (1995). During these initial conversations, the modeling group learned about the KDI project, and about theoretical conversations related to trust and collaboration within the CTG team. The conversations included such terms as “path dependence”, and “halving times,” which reinforced the belief that system dynamics modeling would be a suitable method to develop theory associated with this project.

[4] The Center for Technology in Government at the University at Albany develops applied research and partnership projects to foster innovative ways to improve government services through the understanding of the management, policy, and technology dimensions of information use in the public sector. Additional information about the center can be found in its web site at http://www.ctg.albany.edu/

[5] Knowledge Networking in the Public Sector, funded by the National Science Foundation, which the group at CTG refers to as the KDI project.

Table 2. Project Time Line

Date	Activity
Jan/2001	Modeling group starts conversations with CTG'a gatekeeper and potential participants
March/13/2001	First project scoping meeting
March/20/2001	Second project scoping meeting
March/29/2001	Third project scoping meeting
April/13/2001	First Modeling session
May/08/2001	Second modeling session

Three more meetings took place during March 2001. In those meetings the modeling team and Center staff worked through the main objectives and expected products of the GMB sessions. Because of its richness in dynamic stories, and potential to theory development, the group decided in March 29 to focus the modeling effort in one of the seven cases in the KDI project, the development of the Homeless Information Management System (HIMS). The field research for the HIMS project focused in the development of a prototype of an integrated information system to support evaluation and management of homeless programs and services in New York State. The HIMS prototype integrated data from case management and financial systems in several homeless shelter providers. To be successful, the project required participants from the state agency responsible for shelter oversight to work in a highly collaborative way with managers from a wide range of homeless shelters in New York City, Westchester, and Suffolk counties. Because of the diversity among individual shelter practices, shelter managers had the challenge of collaborating among themselves and with the state agency to develop data standards and a common service model.

The initial GMB sessions took place in April 13, and May 8, 2001. Each session was scheduled as a four-hour meeting from 8:30 AM to 12:30 PM. The first meeting focused on the elicitation of the dynamic characterization (dynamic hypothesis) of the collaboration mechanisms present in the HIMS case in terms of reference modes and a causal structure. The second modeling session focused on the presentation and exploration of a first simulation model of the case.

Effort on Project

The current section includes a description of the amounts and distribution of the effort required to accomplish the project objectives, and provides a reference "picture" of the effort needed for similar initiatives using this GMB approach. The amount of effort documented includes the activities of both the facilitation and the client groups.

Facilitation Team Activities and Effort

The GMB project required a total of 155 person-hours from the modeling team (see Table 3). The team consisted of five members, two senior modelers, two junior modelers, and a gatekeeper. As shown in Table 3, model formulation was the most important activity in terms of the effort allocated to it, followed by effort in the facilitation process (almost half of the effort in the project). The four modelers engaged in a two-hour conceptualization meeting represents a total of 8 person-hours of project activity. Similarly, the modeling team engaged in the two four-hour GMB sessions represents 32 hours of facilitation effort. The senior modelers played the roles of facilitator and modeler/reflector during the GMB sessions, and the two junior modelers

played the role of recorders of the meetings, and worked in the formulation of the model produced during the modeling process.

Table 3. Modeling effort

Activity	Person-hours	Percentage
Coordinating effort	15	9.7%
Concept Model	20	12.9%
Planning Meetings	15	9.7%
Facilitation	32	20.6%
Model formulation	45	29.0%
Writing Reports	20	12.9%
Gatekeeping	8	5.2%
Total	155	100.0%

Managing collaboration is reflected in Table 3 as three different activities: coordinating the effort, writing reports, and gatekeeping (43 person-hours or about 28% of the effort). These activities involved the coordination of the work between the modeling team and the client group, and the development of progress reports to keep the group informed about the process. Coordinating the effort involved mainly phone calls and email messages to set meeting dates and times. Gatekeeping involves the effort needed by the CTG research director to keep contact with both, the modeling and the internal teams.

The last group of activities represents the effort in planning the GMB sessions. These activities accounted for about a quarter of the total effort on the project. These activities included the developing a concept model and planning the scripts to be used during the sessions. The effort accounting includes participation of facilitation team members in the scoping meetings.

In this way, the modeling team effort was distributed across three main task groups: modeling and facilitation, planning activities, and managing the collaboration. The modeling and facilitation activities represented about half of the total effort on the project. Planning activities and managing collaboration activities accounted for the other half of the effort divided more or less evenly between activity planning and managing collaboration.

Client group activities and effort

The client group effort was 68 person-hours (Table 4). The five activities listed in Table 4 could be grouped in two categories: scoping and GMB sessions. The participation of the client group in defining the scope of the project represented about 40% of the total effort, and the actual participation in the GMB meetings represented 60% of the total effort.

Gatekeeping is often a key role in decisions about the involvement of other members of the client organization in scoping activities. In some GMB projects, the gatekeeper is the only client involved in these planning activities. Given the nature of the project, and CTG's organizational culture, however, after an initial meeting with the gatekeeper and the project director at CTG, the team decided to engage the KDI team in the scoping process.

Table 4. CTG's client group effort.

Activity	People involved	Person-hours	Percentage
First project scoping meeting	1	2	3%
Second project scoping meeting	8	16	24%
Third project scoping meeting	5	10	15%
First modeling session	5	20	29%
Second modeling session	5	20	29%
Total		68	100%

Project Products

The results of GMB-related activities include process-related products and reports, and a series of conference presentations reporting on the project results. The process-related products include the scripts, agenda, artifacts, and reports from the GMB sessions. The simulation model constitutes the main artifact of this initial exploration with the CTG team. However, the exploration also demonstrated that system dynamics can be an effective tool for building theories about collaboration, trust development, and knowledge sharing in information-technology projects in interorganizational contexts. Some of the results of the GMB effort were presented at the 2001 International System Dynamics Conference in Atlanta, GA (see Cresswell *et al.* 2001a; Cresswell *et al.* 2001b), and at the 2002 Hawaiian International Conference on System Sciences (see Cresswell *et al.* 2002b).

Scripts for Group Model Building

The scripts used in this case followed the general framework developed in several other interventions facilitated by the modeling group at Albany (Andersen and Richardson 1997). The script content is organized in three different subsections. The first describes the script's objective, the second subsection describes how the script is to be used, and the last subsection includes a brief assessment of the application of the script. Each section includes descriptions of the raw products of the process. The series of scripts presented in this section constitute a comprehensive description of this GMB approach.

SCRIPT 1: Activity and Script Planning

Objective

Planning each GMB intervention requires selecting the scripts to be used during the modeling session. As described in previous work (Andersen and Richardson 1997), the appropriate metaphor for this planning stage is preparing for a theatrical performance. This includes creating a detailed plan of divergent and convergent tasks to elicit variables and model structure combined with continuous reflections about the process, facilitated by presentations from the modeler/reflector. The central focus of attention for this session is creating a communication artifact: the final schedule for the modeling process. This artifact is used by the facilitation team to coordinate the performance. Typically the format of the final schedule is a planning sheet that includes three to four columns. The first column shows the scheduled times for the activities. The second column includes the public agenda to be shared with the group. The third column

includes a detailed agenda to be used by the team, and the last column includes notes about the logistics and materials needed to prepare each part of the meeting (see Table 5 below).

Process

During a planning session involving the facilitation team, the group created the facilitation plan shown in Table 5 for the GMB session held in April 13. In this particular project, the script planning incorporated a series of pre-meeting and post-meeting activities. The pre- and post-meeting activities involved engaging the gatekeeper in the planning process to get additional feedback about the appropriateness of the initial plan, as well as the preparation of materials and reports to the client group.

This planning technique provides for structuring the process at a fairly detailed level. These GMB-session activities were scheduled in small blocks of time (the duration of each activity is shown in parenthesis after each item in the facilitator's notes column). As shown in the schedule, the shortest block was planned to be 10 minutes, and the largest block was 95 minutes. The most common block duration was quite short, approximately 15-20 minutes.

The decision making for creation of the planning table was iterative. That is to say, the group started by scheduling the specific tasks for the meeting, coming back to the pre- and post-meeting activities at the end of the planning session. Ideas about the preparation and materials needed were added during the initial scheduling, but new ideas were incorporated in a final review of the schedule. The plan included detailed task assignments for specific logistical tasks and preparing objects to be used in the meeting.

Assessment

The planning stage was previously compared to preparation for a theatrical performance. However the execution phase is much more improvisational, and is better compared to a "chess player, a jazz musician in concert, or a football coach executing a game plan. All three of these examples have in common the notion of flexible improvisation after compulsively detailed advance planning" (Andersen and Richardson 1997, p. 113). This aspect of the modeling process resembles the fuzzy task type described above.

The group has developed some strategies to make changes to the session plan during the execution. It is common to have a brief meeting just before the GMB session, and several conversations during the break to adjust or re-direct the course of the meeting. In fact, the modeler/reflector sends signals to the facilitator as in a baseball game, asking for permission to re-direct or focus a conversation or to force a break to discuss alternatives to the facilitation process. Based on the flow of the group process, the facilitator can respond to, ignore, or delay attending to the modeler/reflector's signals or offers to participate.

Table 5. Detailed Meeting Agenda for the Modeling session of April 13, 2001

Time	Public Agenda	Team Agenda	Preparation and Materials
Pre Meeting	• Agenda Check and Approve with Tony • Meeting Logistics Complete	• Create this script, ask Tony for comments • Create the Concept Model • Brief George • Complete Logistics	• Concept Model • Meeting Box from Roberta • >2 Laptops loaded with Vensim, Graphics, WP, Spreadsheets • Cling Sheets and flip charts
8:30	• Review Agenda for Day • Purpose Discussion & Clarification • Concept Model: A Fast Overview of Final Product • Boundary Clarification Stakeholders, Actors, and Sectors in the Model Key Variables and the Reference Mode Key Variable (especially stocks) elicitation	• Do fast hopes and fears as an exercise for boundary clarification. (15) • GPR Present Concept Model (20) • Perhaps say more about project models • Stakeholders, actors, and sectors (20) • Elicit key actors cluster them into sectors • Straight forward definition of and then elicitation of key variables, especially stocks (15) • Draw reference modes in pairs or triples (40) • Discuss some form of sticky dot voting on list and then reference modes to include in final model	• Practice concept model • Read up on project models -- have some structure at hand • Carefully review structures in Laura's paper -- get Laura's paper • Have a beam projector ready for concept model • Nacho and Luis prepared to capture all products electronically on graphics package, Vensim, or WP. • Capture people and products on shots
10:20	Break		
10:30	• Stock Mapping • Feedback Loop Mapping • Modeler Feedback • Next Steps and Future Tasks	• Bring forward key variables as stocks. Arrange and stock and flow chains. If no chains, bag the distinction. (15) • What Script for loop elicitation (95). Punt from here on- George, what do you think? • Clarify what model team will do by May 8 (10) • Clarify what CTG team will do	• Lots of drawing space • Capture structure sketches in Vensim
12:30	Lunch		
Post Meeting		• Create minutes of the meeting (less than four days) • Create first cut dynamic model • Share products with group c/o Tony • Create Agenda for next meeting • Check Agenda with team c/o Tony	

SCRIPT 2: Logistics and Room Arrangements

Objective

The commitment of the group to the model building tasks and attention of a key management team, particularly over an extended period of time, is critical to success. This commitment depends in part on the qualities and comfort of the physical facilities and the smooth handling of logistics for the sessions. This should include removing the participants from their phones and work site and providing a relaxing change from routine work. Multi-day sessions should be located and planned to provide high quality lodging, meals, and opportunities for social interaction. As one senior facilitator once told us, "Get any team away from their phones, feed them well, and take care of their needs and they will do brilliant work."

High quality physical facilities for this case included:[6]

- **White Boards** - large (greater than five foot by twelve foot) erasable writing surface. IF these are not available, portable white boards may be brought on site, or Mylar "cling" sheets that allow a white board to be "built" on any smooth surface, including glass window walls.

- **Smooth Blank Walls** - three smooth surfaces for posting Hopes and Fears, Stakeholder, and other maps made up of pieces of paper mounted with masking tape or a glue stick on a wall.

- **Flexible Furniture Set Up** - moveable tables and chairs allowing flexible seating arrangements in a circle, "U" shape, in small clusters, and other shapes appropriate to the size and composition of the modeling group. When possible, the room was set up the day before based on a design to fit the planned activities. The space design includes a key focal point from which the facilitator works as well as a dedicated space, usually in the back of the room, where the rest of the modeling team can set up and do its work.

- **Projection Equipment** - both an overhead projector for showing hand-drawn acetate slides and a digital projector connected to a laptop for software-based models.

- **Eight-hour chairs** (a term of art used by most off-site logistic managers to refer to seating for a full day's work) - the meeting room was furnished with chairs that swivel and have multiple adjustments. These provide the team sitting arrangements for extended periods without inducing back pain.

[6] To support our work, we have a written description of room requirements that we can give to a hotel logistics or room manager. In addition, we maintain a fully stocked "meeting box" with colored paper, glue sticks, white board markers, staplers, and all the paraphernalia necessary to run a meeting. These two advance organization items save us immense amounts of time and effort as we move our work off site.

For some locations, considerable advance work may be necessary to provide similar meeting arrangements. Many commercial spaces used to support meetings are ill suited to meet these requirements. Working wall space is necessary, but many hotel meeting rooms have textured wallpapers or artwork mounted in ways that prevent posting paper or whit board material. Furniture in the form of a fixed long and narrow boardroom table, for example, are poorly suited for a group meeting. Classrooms at a local community college can often be better spaces than hotels spaces.

Process

For this case very little attention to these space requirements was necessary. CTG routinely uses group facilitation processes in its work and adheres too much the same meeting requirements and rules as those for group modeling. The CTG spaces used were specially designed and constructed to support work of this kind and met or exceeded all the meeting room requirements described above.

Figure 1. Room configuration during a modeling conference

Figure 1 is a photograph of a CTG meeting space, showing the facilitator in front of the group and two tables with a computer and projection equipment. The U-shaped seating configuration allows all participants to see each other when they speak. Three of the room's walls are predominately white board space, allowing the modelers write or post the group's ideas. The photograph was taken from the seating position of the recorder and the modeler/reflector.

Assessment

For this case there was little effort or complexity involved in room set up and logistics, in getting all the physical aspects of a meeting in excellent condition. This is not typically the case.[7] However in this example, there was ready access to specially designed space at CTG's home office.

SCRIPT 3: Hopes and Fears

Objectives

The "Hopes and Fears" exercise is often used as an opening activity for a group modeling session. As used in this case it structures the process and supports both focused communication and information processing. There are several possible objectives depending on the type of group that is doing the work. First, if the group has not worked together in the past, this can be a group forming exercise. Participants can introduce themselves as they state their "hopes" and their "fears" for the project. Second, in stating their hope or fear many members make a small speech to the group. If left untold at the beginning, these small speeches often emerge at more disruptive times during the group process. Third, this exercise can help the group identify and share its own goals for the project at hand. The facilitator can often return to this list at the end of the day as a way to measure progress of the project against original intentions. Finally, this exercise often surfaces an interesting list of goals and barriers to success for the project under study. That is, the group members make forceful statements about what they believe to be key values and goals in the system under study. These statements differs from goals for the group in that they often reflect interests of stakeholders not present or are goals for the system under study, rather than for the group modeling process itself.

Process

The process elicits and clusters statements of specific hops and fears from the group members in a structured process. Members of the group are given pieces of colored paper, one color for statements of hopes and the other for statements of fears. The participants are instructed to write simple phrases identifying one hope or one fear on each colored sheet. Usually, the facilitator writes a task-focusing question on a flip chart such as "What are your Hopes and Fears for this project that we are working on for the next several days?" Notice that this elicitation is ambiguous in that it may elicit comments about the group modeling process itself or about the system under study. Initially participants write these phrases working alone to assure maximum diversity of ideas and to avoid anchoring. Then in a round-robin fashion, each individual is then asked to read one hope and one fear sheet to the group. If the group is just forming, individuals are asked to introduce themselves before reading their hopes and fears. If the group is very large and time is short, we sometimes ask the group to start working alone,

[7] In our group, a story about logistics has achieved legend status. It involves a Full Professor searching late at night for a grocery store in rural Vermont to purchase cleaning materials, and then spending much of the night cleaning desk surfaces and arranging the furniture in a community college classroom to prepare for a group modeling session the next day.

but then to break into pairs or small groups of three or four for the final posting of the pieces of paper on the wall.

As each sheet is read the facilitator collects it from the participant and uses tape or a glue stick to post it on a wall, clustering the hopes and fears into similar groups. This can be organized as a two-person task, with one member of the team collect the pieces of paper while the other leads the group in discussing the placement of sheets and the meaning ascribed to the clusters. The round robin collection of ideas continues until all members of the group have had a chance to get all of their ideas out. However, we try not to let any individual place more than one hope and fear at each iteration. A member of the modeling team usually steps back and gives an interpretative reading of the finished and clustered wall, trying to give a single voice to this first group exercise. If possible, the group can be led to consensus about the contents and meaning ascribed to the clusters, creating a shared understanding of the group's goals and concerns. The recorder either takes a photographic image of the wall or types it into a word processor as a list or in some format that preserves the clusters.

Table 6. Unclustered Listing of Hopes and Fears taken at Opening of First Day

Hopes	Fears
• Product of value for both teams • Make a model that works (shows key dynamics of trust) • Understand the key variables that made BSS a successful project • This is useful to CTG • Understand how feedback SD models work (soft variables) • This is useful KDI • Hope that we can narrow the variables to a manageable size, so that it is a somewhat straightforward model • New insights into HIMS • There is humor in today • That it works so well that we can use it to explore the other projects as well • To be able to use this experience to think about our projects using different lens	• Ability to talk in SD terms • It won't be applicable to us, only to you • Too hard for us • That my own biases will cloud its outcome • This is a waste of time • Too hard • That I won't get it • CTG do not have enough detailed data about BHS • Talk, talk, talk and not get anywhere • Have lunch • Too little time to get to the good stuff • Not understanding or being shown what happens behind the curtain

Assessment

Table 6 presents a simple unclustered listing of the hopes and fears produced by our group. Since the group had been working together for some time, this exercise did not serve any significant group building function. However, almost all of the hopes and fears pertained to the group process itself. This group was most concerned about the value of modeling *per se*, wondering if system dynamics modeling held value as a theory generating exercise for them. Recall that the purpose of the KDI project was to produce

theoretical insights about how knowledge networks develop in public sector IT projects. Notice also that their comments are quite frank (e.g., “This is a waste of time” as a fear) and the group valued humor (“There is humor in today” is a hope of one participant). The facilitator returned to this list of hopes and fears at the end of the first day and near the beginning of the second as a bench-marking exercise for the group’s perceived progress.

SCRIPT 4: Concept Model

Objectives

From the hopes and fears exercise, the conference moves to the presentation of a concept model, i.e., a small model with three to four stocks and two or three feedback loops. The content of the model is always closely related to content of the problem at hand.

The concept model script is designed to accomplish several objectives. The first of them is to clarify expectations about the final products of the GMB exercise. In many cases, the client group has never worked with simulation models of any nature, and having an early example helps them to visualize the main target of the activity. Second, the concept model is used to introduce the grammars, and the basic principles of system dynamics. The concepts of stocks and flows are introduced by the use of a simple structure that uses variables that are familiar to the client group. The iterative nature of the method is exemplified by presenting the model in two or three stages, showing behaviors associated with partial simulations of the concept model. Through the incremental addition of structure and the partial simulations, the client group also learns about the relationship between model structure and model behavior, and that the model is transformable. Finally, the model is used to start the conversation about the problem in dynamic terms. To accomplish the main purposes of the presentation, the model has to be technically correct, but “agonizingly inadequate” (Richardson and Andersen 1995, p. 114), to help engage the client group in the exercise of creating a more adequate theory of the problem.

Process

The presentation of the concept model starts with a brief introduction to stocks and flows as ways of representing a process. The modeler/reflector usually starts by drawing in a corner of the board or in a flipchart the image of a bathtub with a faucet and a drain. Using the image of the tub, the modeler explains that stocks and flows are analogous to the bathtub and the faucet. Stocks accumulate different things like the water in the bathtub, while rates control the inflows or outflows of things in or out the level like the faucet controls the inflow of water to the bathtub. Causal influences or causal links represent information flowing through the system.

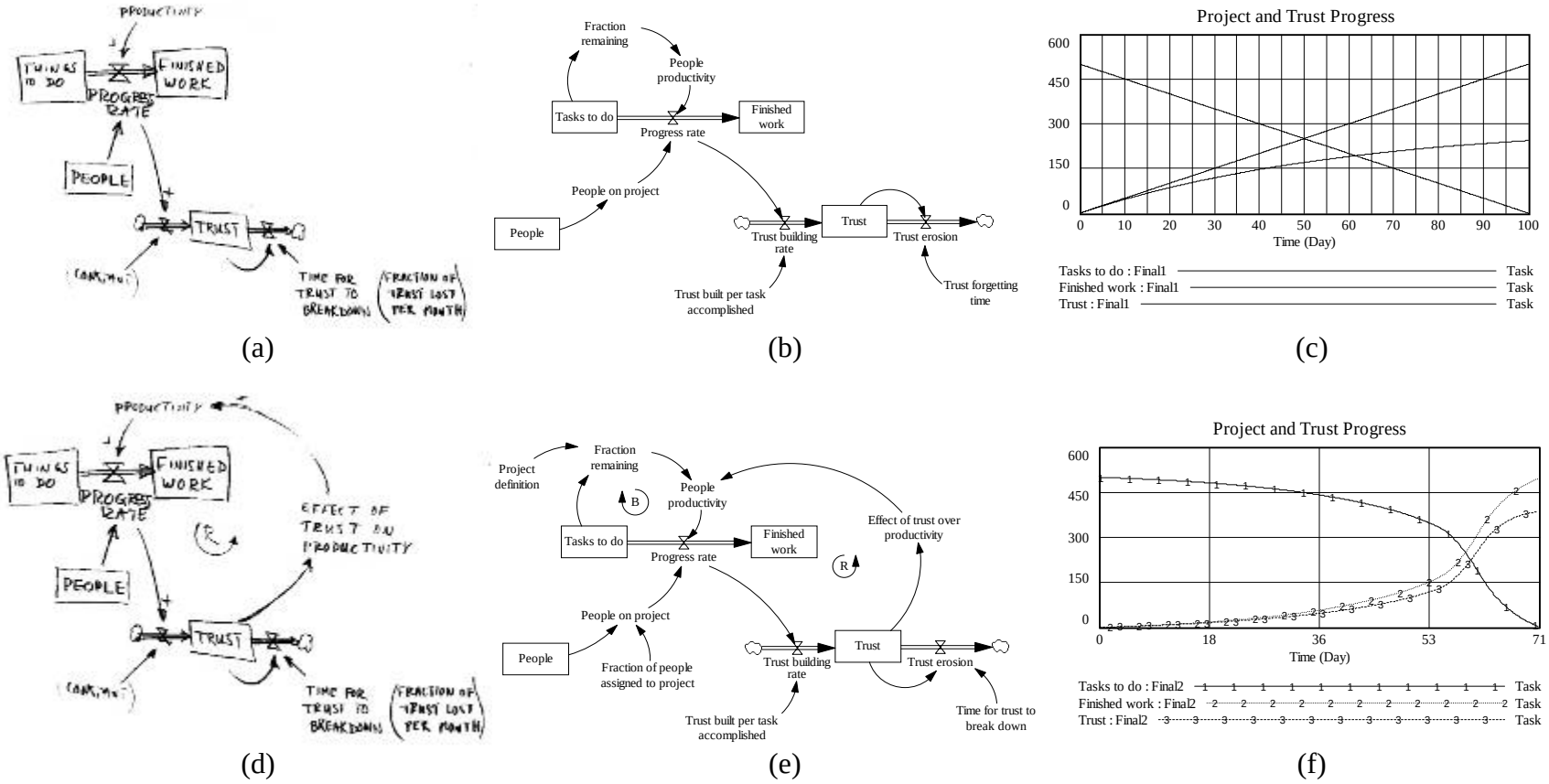
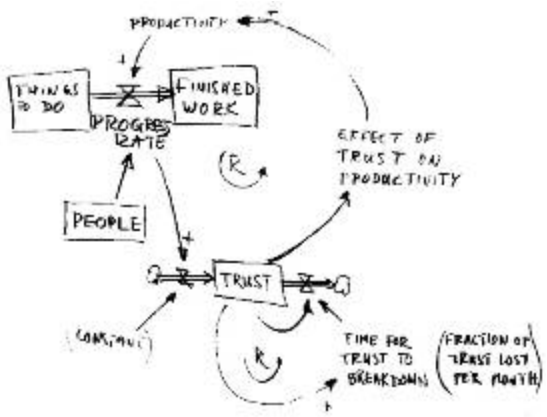
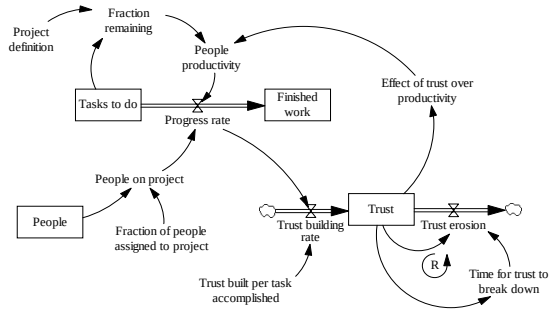


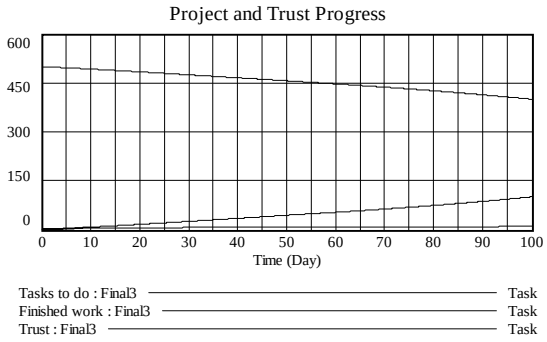
Figure 2. Concept Model sequence of structures and behavior (images captured from the board and Vensim).



(g)



(h)



(i)

Figure 2. Concept Model sequence of structures and behavior (images captured from the board and Vensim) (Continued).

The modeler then introduces the images used in a stock-and-flow diagram using the first iteration of the concept model, presenting it as a story accompanied by a hand drawing in the board (see figure 2a).

In this particular case, the basic story told about the model was about a set of tasks to do in any project. When progress is made the results flow to the accumulation of finished work. To begin with, the model employed the assumption that trust was built as a result of people working together and making progress in the project. The modeler/reflector then comments that it is possible to formulate some algebra associated with the picture on the board, and that it is possible to use a computer program to create this mathematical model, projecting an image of the drawing in a system dynamics software application (see figure 2b). The modeler usually shows some of the equations in the model describing basic assumptions of it. In this case, for example, the reflector showed how, in the model, progress was understood as the product of personal productivity and the number of people working in the project.

The modeler explains that once some algebra is built into the drawing the computer can calculate the way in which the variables in the diagram behave over time, then runs the model. The results of the run show how the dynamic behavior of a system can be expressed in terms of graphs over time. The results are discussed in such a way as to clearly communicate one of the main assumptions in System Dynamics modeling, that system structure is tightly connected to system behavior. Thus, the structure shown in figure 2b, produces the behavior shown in figure 2c.

The modeler proceeds to identify many ways in which the model is wrong, and how it can be modified to make a richer, more appropriate picture of the problem. The modeler then adds some additional structure to the white board image, telling a story of a new assumption represented by a feedback loop, reinforcing in nature. This leads to a discussion about the differences between reinforcing and counterbalancing processes (figure 2d). Then using the projection of the computer-based model, the modeler shows the new image (figure 2e), runs the model, and shows the new behavior (figure 2f). The model's behavior with the new piece of structure further demonstrates how variations in structure affect how the model behaves over time. In this particular case, the presentation went to a third iteration in which more structure was added, and new behaviors were commented (figures 2g, 2h, and 2i). The whole exercise took about 20 minutes.

Assessment

Given the pedagogical and practical purpose of the script, we have found that concept models are tricky to build. However, the group has also accumulated a series of principles or heuristics to guide the formulation and presentation of concept models:

- Use a simple image such as the bathtub to explain the concepts of stock and flows.
- Present only two to three stocks in the first iteration of the model.
- Use algebra that will be easy to understand by the client group, even if that implies the use of weak formulations.
- Use a clearly unrealistic model, so the group can develop it.

- Name variables in a conceptual rather than a mathematical way (i.e. avoid names that include words such as “ratio”).
- The structure added in each iteration should make dramatic differences in model behavior.
- Show the most striking or realistic behavior in the last iteration.
- Use at least two, and at most three, versions of the concept model.

SCRIPT 5: Variable Elicitation

Objectives

Variable elicitation is a script used to start the group conversation about developing a consensus-based model of the problem, and a conversation about the problem boundaries. The objective is to identify as many problem-related variables as possible, prioritizing them and making an effort to identify key stocks to be used in the modeling. The key variables elicited in this process are usually the main input to other activities during the session.

Processes

Variable elicitation is similar to the process described in the hopes and fears script above. The script initiates with a divergent exercise usually done individually. Participants are given sheets of paper and asked to write as many problem-related variables as they can. As in the hopes and fears exercise, the facilitator writes a task-focusing question on the white board or flip chart, such as, “What are the key variables affecting the process and outcomes of the HIMS project?” The facilitator gives the group a few minutes to work individually on their lists. Once they have finished the individual exercise, we use a nominal group technique, such as round robin, to put all individual variables in the board (see Figure 3). When a variable name is open to several interpretations, the facilitator asks the sources for a brief description or definition of the variable, including the units in which the variable can be measured. The facilitator writes the variable name on the board, including any additional information in parenthesis (see Figure 3).

The second phase of the script is a convergent activity in which simple voting mechanisms are used to prioritize the variables. Usually, individuals can vote for as many variables as they want. The number of votes for each variable is also written down in the board (circled numbers in the board represent the number of votes to each variable). Similar to the hopes and fears exercise, a member of the facilitation team makes a summary of the variables on the board, while the recorder captures the products of the process either photographically or in a word processor. The complete script took from 15 to 20 minutes, five minutes for the individual work and the rest for sharing and clarifying variables.

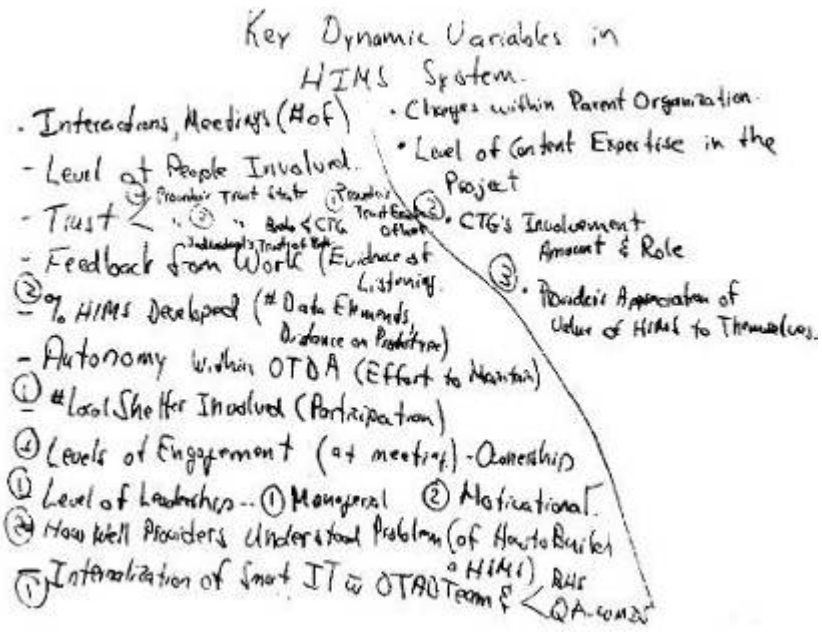


Figure 3. Key dynamic variables elicited in the board (image captured from the board)

Assessment

Although the script is only the very initial part of the knowledge elicitation, it is important to start working towards the identification of key stocks and rates to be used in the elicitation of the problem structure. The effort is reflected in the variable names showed in Figure 3 (all variables that start with "Level of"). This effort is important for the structure elicitation phase as practiced by the group, which usually focuses on stocks judged as important by the group.

SCRIPT 6: Reference Modes Elicitation

Objectives

The next script typically followed once a series of variables has been elicited and prioritized involves the elicitation of reference modes associated with those variables. In some cases a series of reference modes can be prepared in advance with the help of the project gatekeeper, However the group frequently engages in defining reference modes when the problem lacks a precise dynamic definition. The objective of this script is twofold. First, the task is designed to elicit as many dynamic behaviors and stories about those behaviors as possible. Second, the script provides for continued probing of system boundaries, purpose, audience, and policy levers of the problem. These are key to problem definition and the creation of initial vignettes of a dynamic hypothesis.

Process

Reference mode elicitation is mainly a divergent task. It starts with participants working alone, in pairs, or in triples to draw graphs representing behaviors over time of individual variables deemed important (see Figure 4). Usually, the facilitator writes a task-guiding

description in the board. The description asks the group to use a separate sheet for each variable, with the horizontal axis for time, marking the initial and final dates of the behavior sketched. They then draw a line showing changes in the chosen variable over that time frame, annotate the graph with any important event that helps to explain changes in the behavior of that variable. The facilitation team usually spends time walking around the room, attending to questions from the participants, and helping them in their thinking process.

Figure 4. Reference mode elicitation (individual work phase)

Once the pairs or triples have finished their work, they start sharing each reference mode accompanied with a "story" that explains the behavior in the graph (Figure 5). The facilitation team probes frequently to clarify time boundaries, important events, processes and actors involved in the problem at hand. In order to assure that all individuals shares their thoughts, each presents one reference mode at a time, proceeding to each member of the group in several iterations. The complete activity usually takes about 45 to 60 minutes, 15 to the individual work, and the rest sharing behaviors and stories.

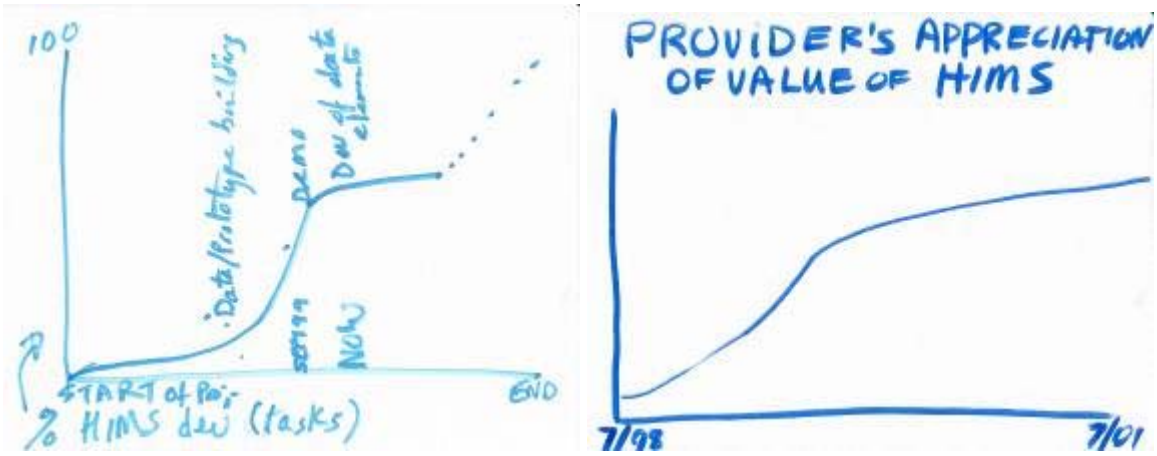


Figure 5. Sample reference modes elicited during the session (scanned from original pieces of paper used in the GMB session).

Assessment

Probing, and reflecting back the group thinking in ways that help the process of boundary clarification are important elements in effectively defining the problem and eliciting its dynamic behaviors. Usually, the team member who plays the role of facilitator executes both activities. However, the modeler/reflector frequently asks permission to participate proposing images that clarify the conversation or redirect the conversation about continuous, dynamic processes. The guided process helps the group to create consensus about main processes, actors, and time horizon for the problem. Figure 6, for example, shows a diagram suggested by the modeler/reflector to clarify different stages in the HIMS project. This diagram was then used to select the time boundary for the model, which focused on the prototyping/requirements definition stage of the project, where the processes of collaboration, trust development, and knowledge sharing were most interesting to the CTG team.

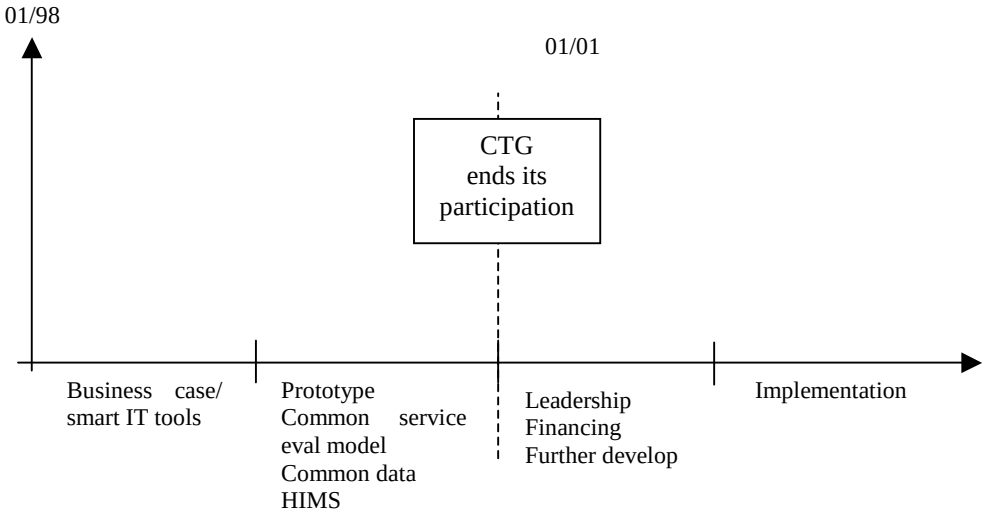


Figure 6. HIMS boundary clarification (captured from the board in image editor)

SCRIPT 7: Structure Elicitation

Objectives

One of the most important tasks during the conference consists of eliciting from the group a causal structure that explains the system stories and behaviors discussed in the previous activities. The purpose of the activity is to capture the key endogenous mechanisms that have the potential to explain the observed behaviors or dynamic hypotheses.

Process

The group has followed several scripts to elicit model structure. For this specific case, the script used was the classic and straightforward direct elicitation of structure. During the scheduled break after the reference mode elicitation script, the facilitation team selected a couple of key stocks from the morning conversations. The facilitating team selected the

process of building the prototype, and the development of understanding about the benefits of HIMS as the starting point because of the emphasis on those variables during the morning conversations. In this way, the facilitator started the eliciting process by suggesting that CTG's involvement in the HIMS project consisted in building two stocks, prototype components, and common understanding of the shared information system (stocks at the center of Figure 7). The facilitator explained that these initial stocks were initial simplifications of the system. For example, the boundary clarification process led the group to visualize three main and closely related project activities: development of a set of common data elements, of a common service model, and of the HIMS prototype itself. All three project activities and products are initially represented in a single stock called "Feasible prototype components."

The facilitator then told the group that the only way an accumulation can increase or decrease is by its associated flows. In this way, he asked the group to identify the variables that help to open or close the faucet of these two stocks. The client group then started to suggest causal relations linked to these two initial stocks and their corresponding rates. The facilitator continually probed the group about the nature of the causal relationships while drawing them on the board. After adding a couple of variables and causal relations, the facilitator summarized by telling the story embedded in the model so far, asking the group to add further causal explanations. After about 90 minutes, the group created the causal structure in Figure 7.

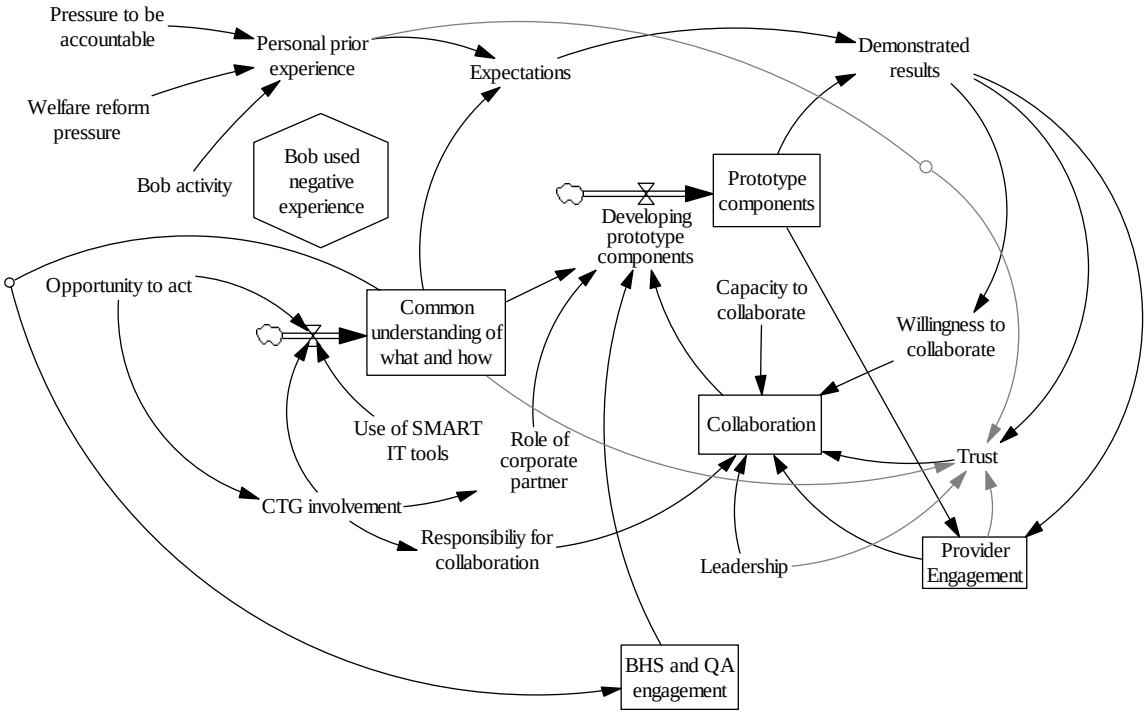


Figure 7. Structure elicited from the group (captured from the board in Vensim)

Assessment

Over the years, the group has experimented with different strategies to elicit model structure from groups. The main limitation of the specific script used in this conference is the risk of having a discussion overguided by the group facilitator, given that client teams are not used to think in loop terms at least at the beginning of the conversation. The main advantage is that it is flexible (used in any situation), and easy to get ready for (the two key stocks were selected during a 15-minute break).

During the beginning of the conversation about structure in this conference, the group showed a tendency to create causal connections from each variable to the rest of the variables in the model. Such a tendency is not rare, given that most variables have some sort of relationship in the world. However, the facilitator stressed the importance of a more selective thinking about causality with the purpose of reaching a powerful and parsimonious explanation of the project success.

Initial aggregations such as the aggregation of all project products and activities in a single stock and flow can also create some sort of conflict with the client group, who is eager to create a detailed picture of the system under analysis. Usually, the facilitator or the reflector differentiates between detail complexity (many disaggregated processes), and feedback complexity (a rich feedback story with many loops), explaining that System Dynamics modelers have found that it is much more easy to increase the detail complexity once an appropriate level of feedback complexity has been reached than to increase feedback complexity when the desired level of detail has been reached.

A very important element in the process is to write down (or erase) all group ideas on the board, even if they cannot be included easily as part of the feedback story. For example, the facilitator in this exercise wrote down inside a hexagon an element of the story important to the client group, but hard to integrate into the story ("Bob used negative experience").

SCRIPT 8: Reflector Feedback

Objectives

Each iteration of structure elicitation is followed by a structured reflection about the group's thinking lead by the modeler/reflector. The purpose of the presentation is to summarize dynamic insights and stories told by the group as a recapitulation of the work so far. In some occasions, the activity also serves the purpose of clarifying fuzzy ideas or capture additional information about model structure that will be needed to the formulation of the model. In a sense, the exercise is also a translation of the work developed by the group into a more operational diagram that may use pieces of structure generated in previous system dynamics applications.

Process

The reflectors presentation is a story telling exercise supported by a series of diagrams created by the reflector during the group discussion. Diagrams and notes are usually captured in overhead transparencies using markers of different colors. Each diagram

presented is accompanied by reflecting the group elements of the conversation using some of the words and sentences used by the group. Following classic system dynamics practice, a more or less complex structural diagram is presented in different "layers". Each layer is prepared in a different overhead transparency, and transparencies are placed sequentially one over the other in an overhead projector (see figures 8a to 8d). The presentation includes comments about how the more operational version of the diagram helps to clarify causal relations and important feedback, and continuous confirmation of the adequacy of the diagram as a representation of the group thinking. Some of the phrases used frequently during the presentation are: "I listen to you talking about…", "the conversation moved then into…", "does it make sense?", and "does it capture what you were saying?." The presentation took about 15 minutes, and was the last activity of the first modeling day, only followed by a brief conversation of the work to be developed between the two modeling sessions.

Assessment

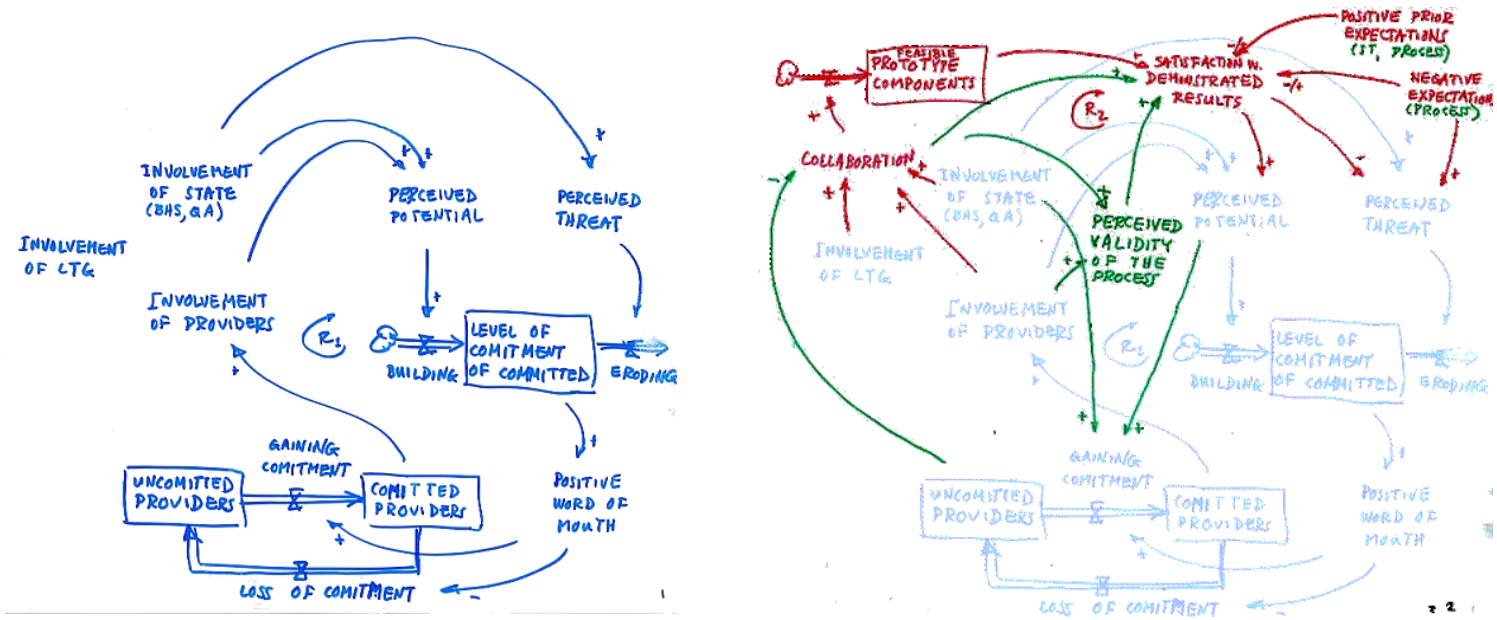
Empirical evidence shows that the reflector summaries of insights are key to a successful exercise of GMB (Maxwell *et al.* 1994). It helps to capture the main insights from the complex diagrams created during the structure elicitation activities that "overwhelm cognitive capabilities and produce distortions of supposed insights" (Andersen and Richardson 1997, p. 125). The script constitutes a powerful way to finish a modeling day by helping the group to get a series of structural "chunks" to carry away.

Although the script is designed to be a presentation, listening to the group and using the pen and the eraser continue to be important during the process. During the session described in this paper, the modeler/reflector added variables to the diagram as per request of the group (*perceived validity of the process* or *involvement of the corporate partner*), and added some clarifying ideas to some variable names (comments in parenthesis below *positive prior expectations* and *negative expectations*).

SCRIPT 9: Transferring Group Ownership from One Image to Another

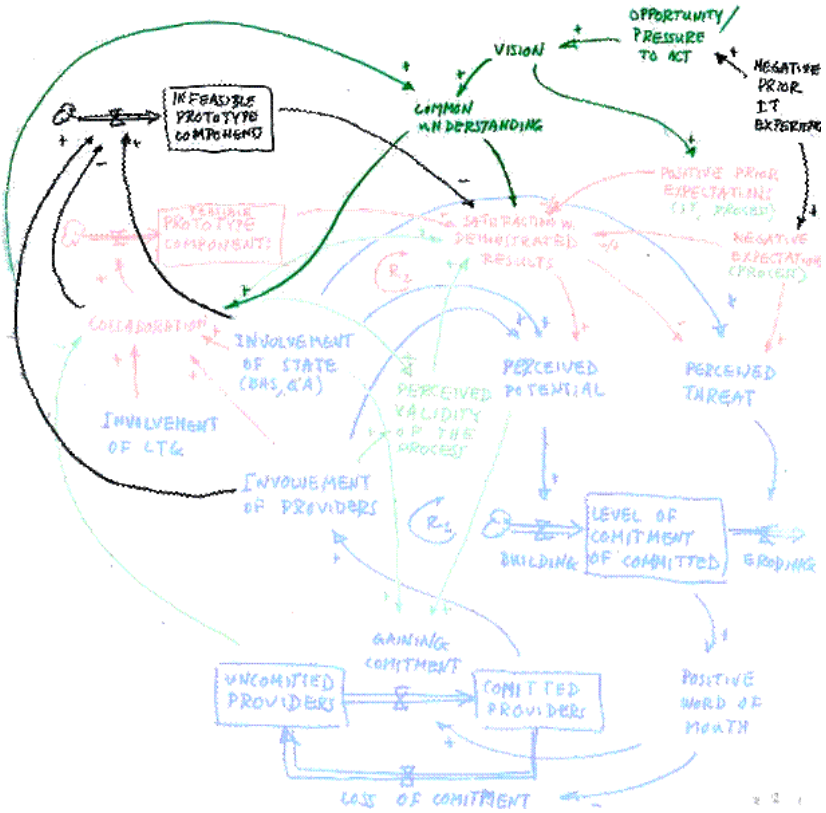
Objectives

After the first GMB session, the facilitation team took notes, diagrams, reference modes and other products from the session to formulate a model based on that set of materials. When they come back to the group, they usually bring a more complex diagram that differs in some extent to the last set of diagrams agreed to during the group conversation. The script has two main purposes. The first objective is to show the group the way in which insights and structures from the first session were incorporated into the simulation model. The second objective is to "get permission" from the group to continue the modeling work starting with the new structural diagram. The script can also be used to move from a complex diagram created in a structure elicitation activity to a simpler and cleaner version created by the modeler/reflector.

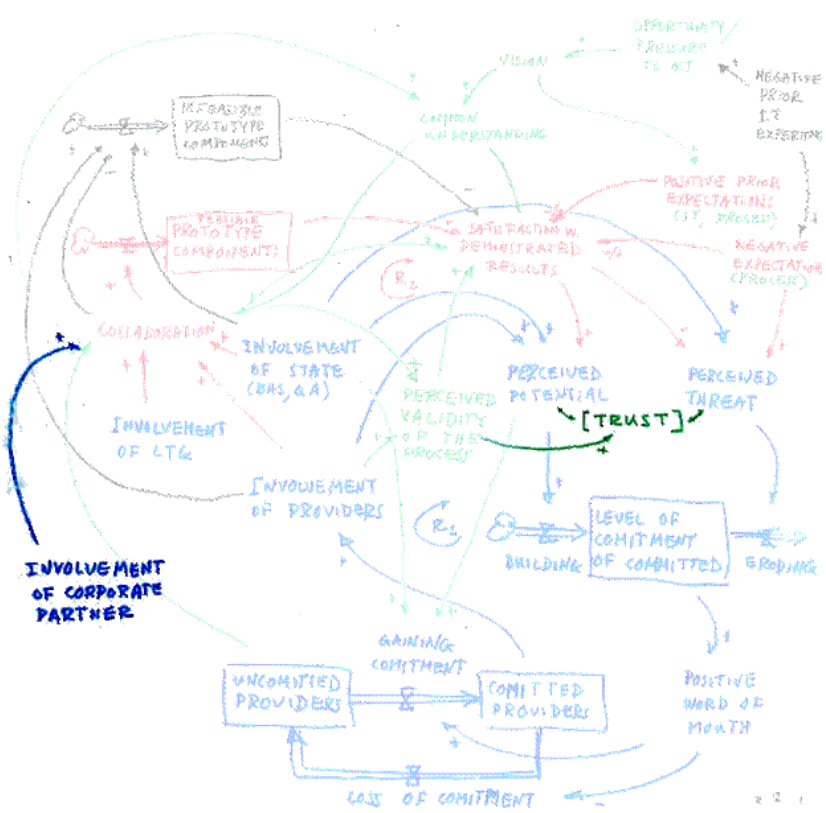


(a) (b)

Figure 8. Layered structure presented during the reflector's feedback (scanned from original overhead transparencies)



(c)



(d)

Figure 8. Layered structure presented during the reflector's feedback (scanned from original overhead transparencies) (Continued)

Process

The activity starts by projecting on different walls of the room the different diagrams to be compared. In this particular GMB experience, the second meeting started with a projection of the images in Figures 9, 10 and 11 in three different walls of the room. Figures 9 and 10 constituted the final "icons" of the group theory from the first modeling session, and Figure 11 was the simulation model formulated between the two sessions. A member of the facilitation team explained to the group how different components of the two diagrams created in the first session were incorporated into the simulation model. The presentation included amplifications of the main sectors of the model to make comparison among the three diagrams easier. The modeling team commented and showed some of the basic assumptions and formulations in the model to the group. At the end of the presentation, the facilitator "asked the group permission" for using the new "icon" as the basis for further theory development. Once the group agreed on the appropriateness of this new "icon", the two images from the first modeling session were taken away, and the conversation focused on the simulation model. The activity extended for about 20 minutes.

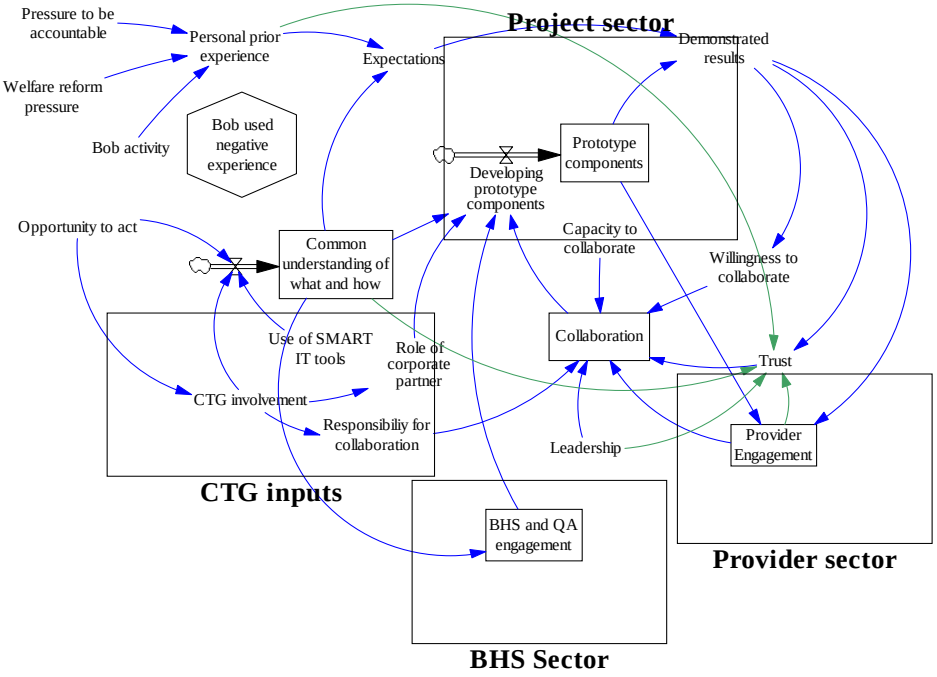


Figure 9. Main elements in structure elicited during the first GMB session

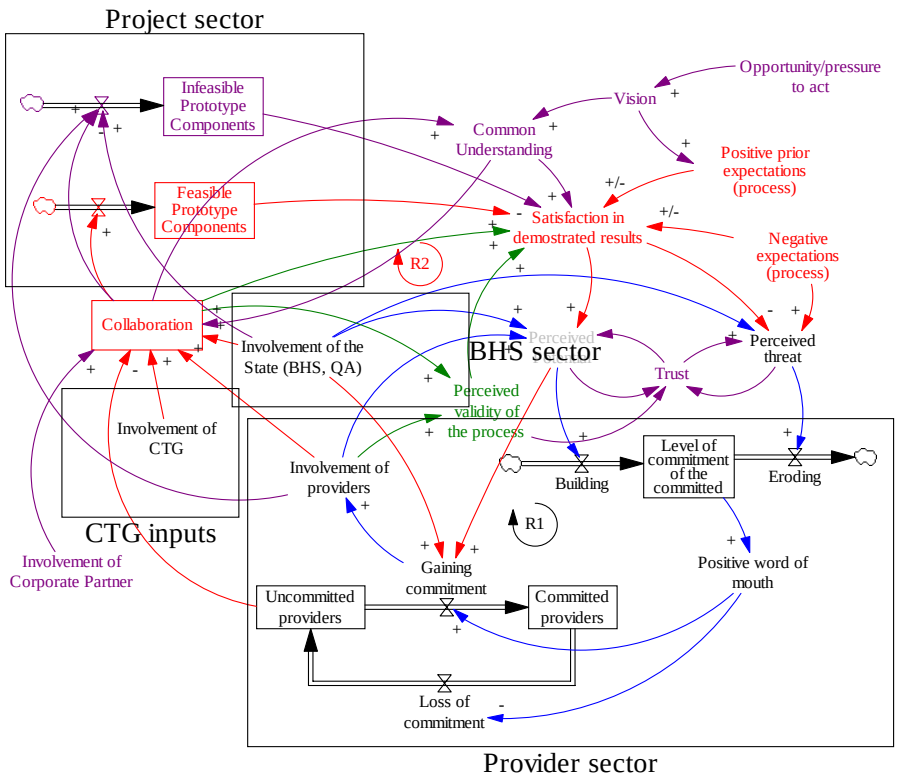


Figure 10. Main elements in the reflector structure presented at the end of the first GMB session.

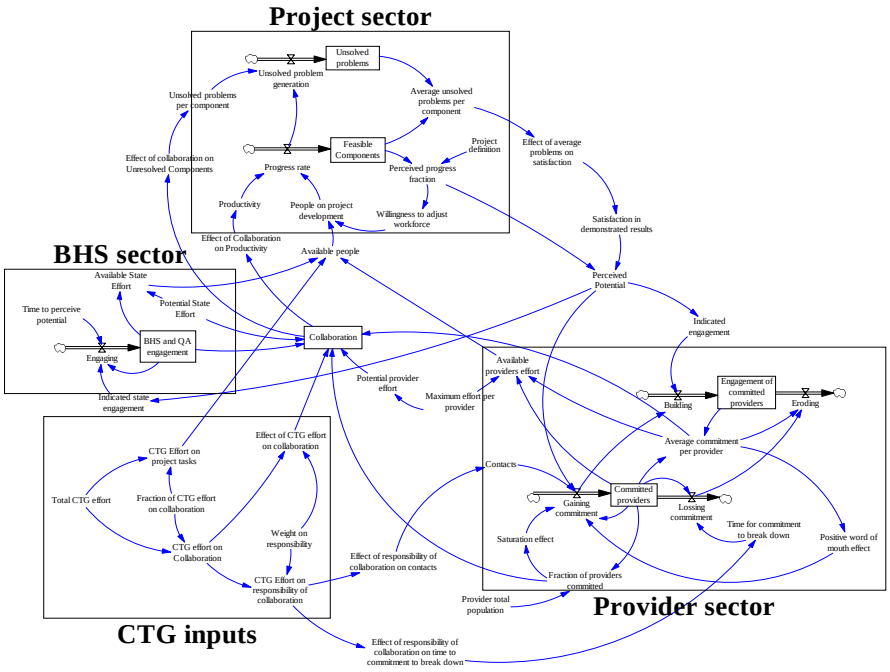


Figure 11. Main elements in the simulation model presented at the second GMB session.

Assessment

An important element to consider for an effective result from the script is to maintain visual consistency among the different diagrams. One way to keep visual consistency is to maintain chunks of variables in the same relative position inside the diagram. The rectangles in figures 9, 10, and 11 were not used during the original presentation, but were added to illustrate that the main "sectors" of the model were kept in the simulation model. Sector diagrams (Morecroft 1982) can be used to facilitate the presentation. When further development of some sector of the model is required, the full picture of the model is kept on a wall of the room while the group works in the structure of a particular sector.

Although in many cases model refinement is needed, extensive experimentation with the simulation model precedes any further structure elicitation. Extensions to model structure are usually guided by group reflections about further steps and the main purpose of the GMB exercise.

POST SCRIPT: Project Update.

General knowledge and understanding from this initial work about trust and collaboration dynamics have fostered a continued effort to clarify specific dynamics found in the HIMS project, and its applicability to other projects at CTG. With the formal incorporation of theory developed by other researchers studying collaboration from a dynamic perspective (Black 2002), the project has yielded one more presentation at the system dynamics conference (Cresswell *et al.* 2002a), two more papers presented in the HICSS conference in 2003 and 2004 (Black *et al.* 2003; Luna-Reyes *et al.* 2004), and a PhD dissertation (Luna-Reyes 2004).

Additionally, the perceived value of system dynamics as a theory-building method by the CTG team triggered the incorporation of a system dynamics component into their longest research project to date, which focus in the study of interorganizational integration of information (Modeling Interorganizational Information Integration or MIII project).

Summary and Conclusion

We have presented in this article detailed documentation of eight different scripts used in a GMB project in 2001. The paper extends the discussion about scripts in GMB (Andersen and Richardson 1997) by presenting a sequence of scripts that constitute a "soup to nuts" description of the group model building approach at Albany. Along with a detailed description of each script, we presented a series of process-related products that illustrate the process in a way that researchers and practitioners interested in building models with groups could use and replicate.

Although the number of documented GMB exercises has increased over time, there is a perception of the need of experimental evaluations of the results obtained through these interventions, and a framework that facilitates such evaluation (Rouwette *et al.* 2002). Although calls for empirical evaluation of scripts consider mainly the evaluation of the outcomes of the intervention (Andersen *et al.* 1997; Rouwette *et al.* 2002), approaches in

decision conferencing argue in favor of process evaluation (McCartt and Rohrbaugh 1989; McCartt and Rohrbaugh 1995).

Issues that are susceptible to such empirical assessment are common to other GDSS approaches: Location of the conference, flexibility of the facilitation, levels of participation in data capture, presentational difficulties, complexity of large volumes of data, control of the team vs. control of the chauffeur/facilitator, group dynamics, conflict, and management of formal and informal languages (Ackermann and Eden 1994; Kyng 1995). Some others are particular to the use of system dynamics or particular approaches to GMB: interaction and improvisation among different roles in a conference room or effect of interventions in managers' mental models (Maxwell *et al.* 1994; Andersen *et al.* 1997). Documenting and reflecting about different approaches is without a doubt an important step towards the accumulation of replicable knowledge in GMB.

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