

## KNOWLEDGE ELICITATION

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### Summary

Involving the client in the process of model construction automatically creates the issue of knowledge elicitation. Although system dynamicists use documents and numerical database, most of the knowledge required to construct a system dynamics model resides in the mental models of system participants. Capturing this knowledge thus becomes of primary importance. At the individual level this is accomplished through interviews, questionnaires and workbooks. At the group level psychologists have conducted research on so-called cognitive tasks (e.g. generating information, evaluating information, making estimations) and have identified under what conditions such tasks can be best fulfilled. For some of these tasks group process techniques have been developed to support a group in performing the task effectively. Building a system dynamics model with a group involves a wide variety of such cognitive tasks (e.g. identifying feedback loop structure, generating stocks and flow structure, estimating parameter values) and the eclectic use of group process techniques.

## 1. Introduction

As Forrester, the founder of system dynamics has indicated repeatedly, most of the knowledge required to construct a system dynamics model resides in the mental models of the system participants. Effectively capturing the knowledge contained in these mental models is of paramount importance.

When thinking about knowledge elicitation several important topics surface. To begin with one can distinguish several sources where relevant knowledge can be found. Methodologists have developed a variety of methods and techniques to elicit information from these sources. Second, knowledge to construct system dynamics models is frequently elicited in group settings. Eliciting knowledge basically boils down to asking questions to the group, which implies that the group will face a so-called cognitive task. Since the construction of a system dynamics model involves a wide variety of cognitive tasks (e.g. brainstorming model variables, quantifying parameters, identifying feedback loops, judging model outcome), knowledge elicitation is a complex process in which the cognitive tasks that the group faces need to be matched with what is known from small group research and the realm of group process techniques. In addition, the group communication process may further complicate the process of knowledge elicitation, particularly if the quality of communication is low and there is a lot of disagreement between group members.

In this paper I will first discuss knowledge sources, next capturing knowledge from written sources and from individuals. Finally capturing knowledge from groups will be described.

## 2. Knowledge Sources and Elicitation Techniques

Researchers in the realms of the social sciences have identified four basic sources of information and accompanying data collection methods to capture that information. A summary is given in Table 1.

Knowledge source	Data collection method
'real life'	<ul style="list-style-type: none"> <li>• observation</li> </ul>
documents	<ul style="list-style-type: none"> <li>• content or document analysis</li> </ul>
individuals	<ul style="list-style-type: none"> <li>• self administered questionnaire</li> <li>• (face to face) interview</li> <li>• telephone interview</li> </ul>
groups	<ul style="list-style-type: none"> <li>• Group interview</li> </ul>

Table 1. Sources of knowledge and accompanying data collection methods.

As Forrester has pointed out, the three types of knowledge sources, which are most relevant for the construction of system dynamics models, are: numerical, written (i.e. documents), and mental (i.e. individuals/groups). In his opinion numerical data sources are the narrowest of the three, while the mental model constitutes the richest source of knowledge. Written sources are also limited, not only because the richness of

information is restricted and modelers cannot query written text, but also because during codification information may be biased and filtered. That is why some researchers have specified more rigid procedures to extract system dynamics relevant knowledge from documents.

As mental models constitute by far the most important of the three data sources the focus of the description will be on eliciting knowledge from individuals and groups.

### **3. Eliciting Knowledge from Individuals**

In order to elicit knowledge from individuals system dynamicists have employed three methods: face to face interviews, self administered questionnaires, and so-called workbooks.

#### **3.1 Interviews**

The most widely used method is the face-to-face interview. Although interviews are a means of gathering relevant knowledge, they may also serve two other purposes. In a number of cases interviews are used as a first step in a larger process of Group Model Building, where the interviews will be followed by one or more sessions and the persons who were interviewed will meet face to face. Preparatory interviews will then also serve the purpose of (a) becoming familiar with the group members, and (b) building rapport with the participants who will later be in the group sessions.

Naturally when interviewing people one follows the normal guidelines for interviewing—for instance by being neutral and genuinely interested in what interviewees report. Being able to listen actively is an important skill in this respect. Generally the interviews will be of an informational conversational type, where the objective of the interview may be to become informed about the problem and to check whether there is consensus within a team on the definition of the problem. The objective may also be to directly elicit knowledge with which a preliminary (or kick-off) system dynamics model can be constructed, which will serve as a start for the group sessions. If the latter is the case the steps required to construct a system dynamics model guide the selection and framing of the questions. When it comes to the type of questions these may be either factual knowledge questions (e.g. identifying a stocks and flow structure), but also of a reasoning type, i.e. ‘why’ questions. These are used to elicit tacit causal reasoning and will thus be predominant when constructing causal loop diagrams during an interview.

#### **3.2 Questionnaires**

Although used less frequently, system dynamics modelers have also used self-administered questionnaires to elicit knowledge. When employing questionnaires, modelers sometimes first construct a small model of the problem and then, through the use of questionnaires, ask participants whether they agree with the model structure or not, and why not. In order to accomplish this both open-ended and closed questions are used. Closed questions are primarily employed when the modeler wants respondents to indicate whether they agree or disagree with something. One may for instance confront

the respondent with a causal statement (e.g. the higher the sales, the lower customer satisfaction will be) and then ask whether the respondent agrees or disagrees with this statement. Open-ended questions are primarily used when the modeler wants respondents:

- To brainstorm (e.g. variables).
- To rank order information (for example rank order variables in order of magnitude of influence).
- To produce causal reasoning.

In the latter case the closed question above for example may be followed by a why question ('why do you (dis)agree?') This will stimulate a person to produce causal arguments.

As may be clear the use of mailed questionnaires is particularly advantageous if members of the group to be consulted are geographically dispersed or if the group is quite large. Questionnaires have for instance been employed in the context of a Delphi approach, a group process technique, which will be discussed in a later section. The largest danger of mailed questionnaires of course is the low response rate.

### **3.3 Workbooks**

A workbook may be considered a flexible type of questionnaire to elicit information. Workbooks typically contain written text as well as diagrams, interspersed with questions and cognitive tasks for the respondent. The cognitive tasks may include such things as a request to adapt causal loop or stock and flow diagrams. Workbooks are most effectively used in between sessions of a Group Model-Building project. They can (a) summarize the discussion of a foregoing session; (b) identify unresolved issues so far; and (c) ask new questions to prepare the subsequent session of a Group Model-Building process. An alternating sequence of sessions and workbooks is a powerful way to keep a Group Model-Building process going and to produce documentation of the process of knowledge elicitation.

## **4. Eliciting Knowledge from Groups**

When it comes to knowledge elicitation from groups, matters become somewhat more complicated. Eliciting knowledge from groups basically involves asking questions, the answers of which will generate knowledge to construct the system dynamics model. Asking questions in turn will create a cognitive task for the group. Small group researchers have made attempts to identify a limited set of cognitive tasks and to conduct research to answer questions about the conditions under which those tasks could be performed most optimally. Part of the answer to this question is the generation of so called group process techniques, i.e. procedures to support specific group tasks in an optimal way. These will be discussed in one of the next sections.

### **4.1 Cognitive tasks**

When it comes to cognitive tasks researchers have for instance identified production or creativity tasks. This type of task is concerned with generating information. In system dynamics model construction it plays for instance a role when people are requested to generate variables to be included in the model. Intellective tasks involve solving problems with a correct answer, while decision making tasks, concern problems which do not have a correct answer but rather a preferred or agreed upon answer. Both these tasks do occur in the construction of a system dynamics model. Building the model structure as partly an intellective (i.e. obvious structure), and partly a decision making task (i.e. non obvious structure). Simultaneously the whole process of model construction to tackle a strategic issue may be a decision making task in itself, by the way. These two task type categories also include tasks like estimating a value and making a choice. Finally, small group researchers have distinguished two types of tasks related to conflict in groups. Cognitive conflict tasks are tasks involving conflicts of viewpoints, while mixed motive tasks involve conflict of interest. Both cognitive conflict and conflict of interest are involved when working with groups to elicit knowledge.

As may be seen, constructing a system dynamics model with a group involves a wide variety of cognitive tasks. Unfortunately, the steps in eliciting knowledge from groups in the context of constructing a system dynamics model cannot neatly be matched one to one with the various cognitive tasks. When discussing the steps in capturing knowledge for the construction of a system dynamics model I will indicate which type of cognitive task is involved and what is the best way to perform that task.

#### 4.2 Group Process Techniques

In addition to cognitive tasks, some researchers have focused on the development of so-called group process techniques. These are techniques, which aim at overcoming process losses, which occur in freely interacting groups. Their objective is to improve group performance by suppressing the process losses. Three well-known group process techniques, which are frequently used in the context of knowledge elicitation, will be discussed: brainstorming, the Nominal Group Technique and Delphi.

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### **Biographical Sketch**

**Jac Vennix** received his Ph.D. from Nijmegen University and is currently professor of research methodology at the Faculty of Policy Sciences of Nijmegen University. He has conducted a large number of projects in a variety of organisations in the areas of system dynamics group model-building and (interactive) scenario construction.

In 2000, he served as the president of the System Dynamics society and is also one of the managing editors of *System Dynamics Review*. He has published a number of articles and books on system dynamics, group model-building, knowledge elicitation, group facilitation and scenario construction. His latest book 'Group model-building: facilitating team learning using system dynamics', was honoured with the Jay W. Forrester Award, for the best work in the field of System Dynamics in the preceding 5 years.

His research interests focus on problem structuring methodology and empirical assessment of problem structuring interventions in organisations. More in particular on how these methodologies (primarily Group Model Building and scenario construction) can assist in increasing the learning potential of organisations.