Cognition Simulation and Learning

Colin Eden, Tim Smithin, and Jim Wiltshire

University of Bath

The purpose of this paper is to describe new computer software that has been specifically developed to aid experiential learning in groups and with individuals. The software is designed to conduct a pseudosimulation involving ramifications and interaction of qualitative ideas, beliefs, attitudes, and values. It has been developed over the past four years through a continual interaction between the state of theory and software, and has been used with a variety of decision-making groups.

Introduction

Management Science and Systems Analysis have developed from a desire to apply science and mathematics to decision-making problems, and the majority of techniques employed by consultants in these fields depend upon highly rational and quantitative assessments of a problem situation. Several years ago we set out to specifically devise a method for helping decision makers, and particularly project groups, to consider about problems which although not amenable to mathematical modeling techniques might be amenable to more qualitative, less prescriptive methods. Our concern was to facilitate thinking, creativity, and learning, with respect to a problem, rather than to suggest possible solutions. We wished to be able to include qualitative ideas, and beliefs and attitudes about both the world of objects and of people in the definition of a problem. Thus organizational politics, differences in values, and orientations within a group were to be modeled in a way which makes them available for analysis. We considered that a sensible starting position was to try and devise a method of explicitly representing people's unevaluated thinking about the situation in which they believe themselves to be involved, inasmuch as language can be used to describe that situation.

Thus although we do not want to suggest that we are attempting to model cognition, we nevertheless would like to represent some of its aspects that are implicit in the language used. In particular we thought that a simulation could be a basis for self-reflection, learning, and creative thinking. A model that is useful for learning need only represent

Address reprint requests to: Colin Eden, School of Management, University of Bath, Claverton Down, Bath BA27AY Great Britain.

Journal of Experiential Learning and Simulation 2, 131–143 (1980)

52 Vanderbilt Ave., New York, New York 10017

0162-6574/80/020131-13$01.75

Colin Eden, B.Sc., Ph.D., has been an engineer, an operational researcher, and presently Senior Lecturer attached to the Centre for the Study of Organizational Change and Development, University of Bath. His main interests lie in the psychology of policy decision-making and search for new methods of helping individuals and groups work with ideas and problems.

those aspects that are significant with respect to the aim of helping the decision maker consider the problem. Thus the model is client oriented, and not necessarily analytically "complete," in any sense. As with any model we are creating an analogue, representing only particular aspects of that which is modeled. It is not intended that the model be a transparent representation of cognition. Our intention was to represent ideas and their psychological meaning rather than to simulate language or sentence construction along lines similar to the work of Abelson [1], Colby [2], Weizenbaum [3], and Muller-Reissman and Rechenmann [4], or those grappling with the creation of Artificial Intelligence. Nevertheless although we are not attempting to simulate cognition in our model, we do consider that the pragmatics of a client-oriented learning objective should not override the need to respect a distinct cognitive psychological standpoint. Our conceptual perspective is to attempt to capture the subjective and idiosyncratic reality of decision makers in the context of the problem as they see it. A helpful theoretical perspective is given by Personal Contruct Theory, which was developed by G. A. Kelly [5] in 1955 as a self-reflexive theory about how people construe their world. It implies the existence of a construct system that people use to make sense of their world. We have attempted to convert Kelly's view of cognition into methods of modeling a construct system that is made up of beliefs and values that are the constructed problem for a person. The model we produce is called a "cognitive map"; it is amenable to analysis by hand when small but in most practical problem-solving situations it becomes so large that computer software is needed to aid analysis and interaction between client and model.

Some Uses of the Software

We shall go on to describe the model-building activity and demonstrate the power of the software for handling large amounts of data. In the examples that follow it might help the reader to consider the following alternative uses for the software, many of which we have tried during the last few years.

1. Self-reflection, self-learning, and philosophizing for an individual [6].
2. Negotiating problem definitions in groups [7].
3. The analysis of idea and belief structures as they are represented in diaries or memoirs.
4. The analysis of conflicting views presented to a commission of inquiry.
5. The facilitation of empathetic exploration of the views of another for example as a part of an orgnizational induction program [8].
6. Team development [9, 10].
7. Aiding participative decision making in collectives or cooperatives [11].

Before joining the University, Tim Smithin, MA, M.Sc., worked in Local Government research on the development of management information systems. Current interests involve decision-making in small, less powerful organizations.

8. The analysis of qualitative research data [12].
9. The analysis of open-ended person to person market research data or research interviews [13].

Principles of Cognitive Mapping

In this section we outline the principles that guide the ways in which we might capture an individual's view of the world in relation to a particular issue. What features do we need to pay attention to? Each individual brings to bear on an issue a wealth of experience and wisdom, and usually possesses more knowledge of the issue and its ramifications than the analyst as an outsider can ever hope to acquire. The analyst does have a role, however, since it is often difficult to access our own experience as cogently and carefully as we would wish. This is perhaps partly because, as Wittgenstein observes,

> "the aspects of things that are most important for us are hidden because of their simplicity and familiarity" [14].

Another possible reason is the fact that our experience and beliefs have been developed over a long period of time and the reasoning behind them and their implications are therefore not easily recalled. We have often therefore, as analysts, taken on the role of careful listener [15], attempting to find the assumptions and concepts that underlie our clients language. For us, listening involves concern, empathy, and attention to individual meaning, an attempt to pull out the underlying structure and assumptions in a client's thinking about an issue [16].

In listening, we need to explore beyond the surface of the words, and consider what a phrase means to that individual, what he or she intends to convey about his or her world. One way of dynamically capturing some of this is to use the implications of Personal Construct Theory. For Kelly, individuals evolve a system of constructs in order to make sense of their world. A construct represents a dimension of meaning that individuals use and that "makes sense to them." Our constructs develop as we discriminate between aspects of our world in order to understand and manipulate events for our purposes [17]. For example, as we listen to someone using the word "respect," the way in which they use it, what they contrast with it, provides the meaning in that context. It may be

"respect"	rather than	"contempt"
"respect"	rather than	"disobedience"
"respect"	rather than	"irreverence"

Each pair of concepts represent psychological rather than logical opposites.

In our experience it is important to recognize the significance of different individual accounts of the "same" event. For instance, in our work with a national charity the phrase "awareness of charity" was frequently used by many officers. When we encouraged individuals to explore this

After eight years in the computer industry, Jim Wiltshire, M.Sc., AMBIM, MBCS, now works as a freelance Systems Consultant. Recent clients include the publishing industry, retail outlets, local government and manufacturing companies. He has a particular interest in the development of interactive computer systems.

in more detail it became clear that some policy disagreements were arising because different decision makers were ascribing subtly different meanings to this phrase, or 'construct', and what it implied [18].

Figure 1 shows a cognitive map constructed on these principles, taken from some work in a local government housing department. The psychological contrasts are separated by the phrase "rather than," and the arrows indicate that one concept has some influence on another. The revelant part of the discussion with the policy maker is shown in Table 1. Maps such as Fig. 1 resemble the content analysis schemes employed by some political scientists (e.g., [19], [20]) but are intended to pay more attention to idiosynctatic expression, assertions, and values.

We regard listening for values as a most important part of our help. This is because individual values are crucial to understanding the meaning

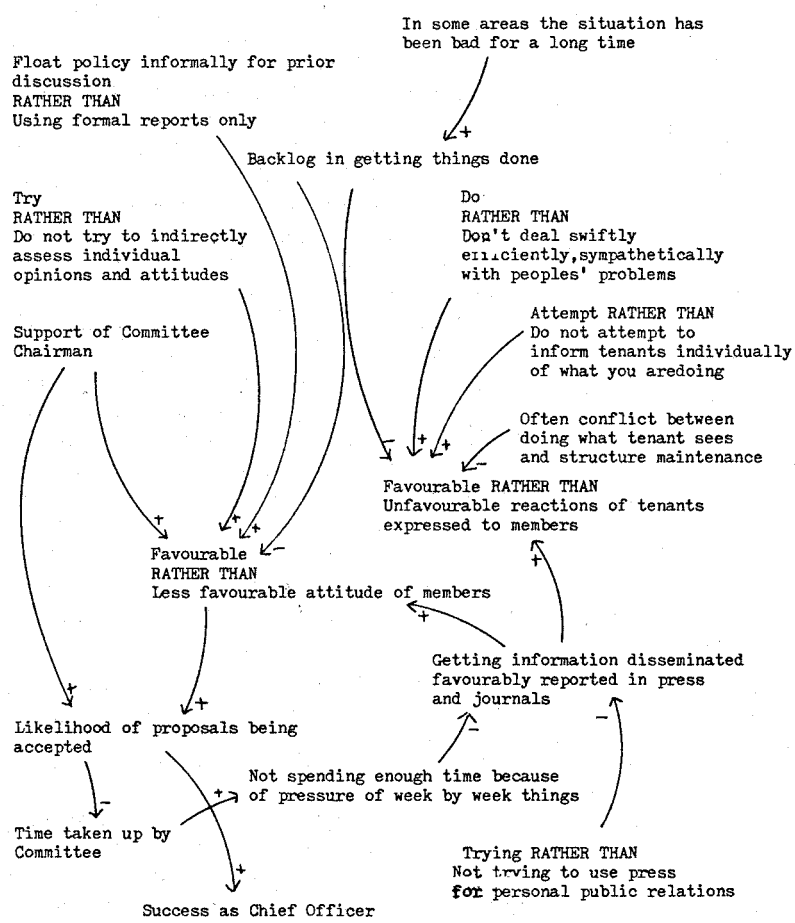


Figure 1
The cognitive map resulting from coding the scenario described in Table 1.

Table 1.
Part of the "Scenario" Described to us by Helen Greaves: Some of the Aspects of Her World To Which She Paid Attention (from [6])

The attitude of members particularly and a host of other people is very important. A general favorable attitude makes an enormous difference to the likelihood of proposals being accepted . . . The department deals with a wide variety of people. We need to be careful to deal swiftly, efficiently, and sympathetically with the large number of people who come to us with problems of one sort or another every week . . . One important factor to be aware of is tenants' reactions as expressed to members. There are problems. For example, there tends often to be a conflict between what the tenant sees needs doing and structure maintenance. Also in some areas the situation has been bad for a long time so there is a backlog in getting things done. We attempt as far as possible to inform tenants individually of what we are doing as well as informing tenants and members collectively through the press and reports to Committee . . .

Relationships with the press are important. The papers are usually willing to disseminate information of interest to the public but they do not take kindly to us trying to use them for personal public relations. I suppose one could say that we should pay more attention to getting the activities of the department publicized and favorably reported. I always feel I could do more if I had the time but the general pressure of week by week things makes it difficult . . .

Of course we don't just maintain contact with members through formal reports. Politics are much more likely to be accepted if you float them informally for some kind of prior discussion and assessment and try and assess the opinions and attitudes from individual members, often really quite indirectly. Of course the support of the Chairman is absolutely crucial.

of the cognitive map for the client, and in predicting possible actions or areas for change. Rokeach has defined value as

> "To say that a person 'has a value' is to say that he has an enduring belief that a specific mode of conduct or end state of existence is personally and socially preferable to alternative modes of conduct or end states of existence" [21, p. 159].

How do we recognize "things that matter" to another person. Eden, Jones, and Sims ([6], Chap. 3) suggest that while this will inevitably be a matter of personal judgment there are some signposts which may guide us:

"can't say why it's better, it just is"

"is internalized"

"involves committment"

"defines a purpose"

"is a criterion for judging outcomes"

"represents a value of something"

For each of us "some things are more important than others," and our value system is more faithfully represented by a value hierarchy in which some values are subsumed within others. The value hierarchy indicates which values have implications for others, and, when included in a cognitive map, is a guide to important and non-important effects and their ramifications. The nature of this hierarchy seems central to discovering those policies or options that will be important for the client.

Below we show two concepts and their link, taken from the map in

Fig. 1 to illustrate in more detail how we attempt to move from "listening to language" to "underlying meaning":

Float policy informally for prior discussion
RATHER THAN
Using formal reports only
↘ +
Favorable attitude of members
RATHER THAN
Less favorable attitude of members

Firstly we try to remain faithful to the language and idiom used by the individual, as this helps him or her to 'own' the model and not be alienated by its form, as many of us are when presented with more abstract mathematical models. The contrast of each construct, as well as representing the meaning in this context, also provides an avenue for potential change. In this instance Helen Greaves clearly envisages at least two ways of influencing members. The plus relationship indicates that the first contrast of each construct is linked; it thus represents the belief that informal floating of policy will lead to a favorable attitude of members. From the rest of the map we can see that "float policy informally" is quite important to Helen Greaves, and perhaps may be connected to significant values. For example, it is certainly a criterion on which some actions are judged, and defines a purpose for some of the actions described. In terms of a value hierarchy it may be linked to other higher-order values e.g., "wish to be an effective chief officer." Such explorations give us some clues about the committment that Helen may have to a course of action and hence suggest the type of help that may be most relevant to her.

The following section describes the software in more detail and indicates the ways in which a client such as Helen Greaves may use a computer to explore a cognitive map.

Using the Software

The software (called COPE—COgnitive Policy Evaluation [22, 23]) has developed gradually through our work with clients.

Direct and immediate use of the software with clients helped to make the interactions with the computer friendly and relevant. Thus the chosen method for operating COPE is command orientated, that is, the user enters one of a number of directives at the main prompt (COPE>). This was found to be a more helpful approach than the alternative method of imposing a set order or sequence to events by guiding the user via a series of questions.

There is also comprehensive hierarchy of HELP messages, which itemizes the commands available to the user within COPE. The command structure is composed of a series of mostly single character operatives, which can easily be memorized, and can be combined to form a more complex command. Thus COPE can be very easily operated at a simple level, but can also become a very powerful tool for a research analyst who takes advantage of the full capabilities.

Often, after some initial interviews, we enter data for the client; then he or she is purely concerned with exploring and appraising the ramifications of the map. In this context, the client only needs to know two sets of options, firstly, the commands to view the contents of the model, and, secondly, the commands to explore the explanations and conse-

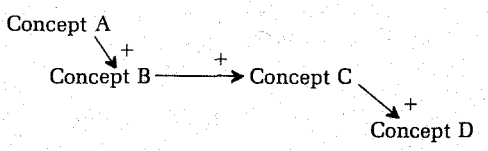
quences of certain concepts. The first of these sets is the LIST command (COPE>L). The List options enable clients to break down and view selected parts of the model before proceeding to explore the concept of interest to them.

Groups

Data are held within the model at two levels, namely, that of the group and that of the concept. Grouping is a convenient way of collecting together concepts that relate, for example, to a certain topic. The group structure is hierarchical; that is, a group can contain subgroups as well as a number of concepts. The use of grouping is one way in which the client can conveniently access concepts and works in the same manner as GUIDE [24].

We have previously stressed the importance of values and the value hierarchy for reflecting authentically our clients' intended meaning, when they describe an issue. The group structure is often used to cluster some concepts around a key concept, which may in part represent a value, or the core of an issue for a client. Typically, therefore, clients may well begin their exploration by listing the groups (value indicators) and then explore a particular group in more detail. (The simple commands COPE>LG lists groups, and COPE>LGC1 lists for example the concepts in group 1.)

A further way of tagging items of interest is to search for key phrases or words with the COPE>L"anyphrase" command. For example, Helen Greaves might in one exploration look for all concepts containing the phrase "HOUSING ASSOCIATION," if this was the topic of interest on that occasion. Another indication that a value may be involved is where the concept has no further consequences the COPE>LH command identifies concepts like this. These "Head" concepts typically represent the believed outcomes of a chain of causally linked concepts:



Potential policies are frequently represented in a similar manner as "Tail" concepts; these concepts, e.g., Concept A, have no previous explanators.

Exploring the Map

Once the clients have used the Listing options to identify interesting concepts, they can then explore the concept in the following ways.

Consequences

If C is typed, followed by the concept code (e.g., COPE>C25), the computer will search for possible consequences of that concept. More specifically it will search in terms of whichever psychological opposite (or pole) of the construct is specified. The first pole is specified by default.

Explanations

Similiarly the letter E followed by a concept code (e.g., COPE>E34) will obtain the explanations of the concept, and E-34 searches in terms of the second pole of the construct.

Path Analysis

If the client specifies a second concept (e.g., COPE>C10,5), the computer will execute a path analysis, looking for routes (any chains of related concepts between concept 10 and concept 1.) Thus Helen Greaves might for instance wish to explore how the policy of deliberately floating items for prior discussion may through a causal route eventually affect other important concepts for example "Members opinion of me as an Officer."

Connotative Links

A further exploratory command available to the client is the K command, which will display all concepts that are connotatively linked to the specified concept, e.g., COPE>K24. Connotative links between concepts indicate that while not ascribing a causal link the client implies that the two concepts are related in some way. When the client obtains an explanation (E) or consequence (C), the computer will print a (K) after the concept if there are any connotative links to that concept.

In complicated routes and sequences of explanation, ellipsis is used to indicate that there are further consequences or explanations for a concept. Thus in conjunction with the connotative tag the client has sufficient information about a concept on the screen to explore further ramifications.

Output from the Model

For a friendly and useful model we feel that it is vital to produce output in a form that makes sense, and is most applicable to, the client's special needs. We have therefore, unlike many computer models, paid considerable attention to providing understandable and flexible output. This includes

1. Options to abbreviate or supress tedious or repititious sections of text.
2. Option to print 3 × 4 in. self-adhesive labels of any concept that could, for example, be used as the basis of a wall chart or other form of large visual display.
3. Option to produce a small section (30 or so concepts) of the map on a computer graphics screen, or "Diablo" printer. (This is currently being extended to enable an interactive use of the map using a light pen.)
4. Option to store any part of the output in a file also to retain all commands entered.

These options and printing commands have been designed to easily used by the client. So for example placing "MAP" before any command will produce a MAP rather than the usual linear text output for that command.

The Analysts Use of COPE

The extent to which the analyst becomes involved in entering data, and helping the client to explore the map, varies from project to project, depending partly on personal preference, and also upon the negotiated

aims of the work. As the above brief description shows, it is quite easy for a client to use and interpret the model without the analyst's aid; entering data is also relatively straightforward (see below). An advantage of COPE, however, is that there are available more powerful and complex analytic aids if needed.

Entering Data

Entering data is quite simple. A concept is identified by a concept number and following text. The text may be separated into the two poles of the concept by slashes. (e.g., 1=/feel members are on my side/feel members are against me/). The description can be overwritten by retyping the line. To delete the concept, the user simply types D followed by the code (e.g., COPE>D18 will delete concept 18). Data may be entered or changed at any point.

Merging Models and Concepts

The analyst can combine two models if desired. After ensuring that the concept codes in each model do not coincide, the analyst can then append one model to the other. This may be useful in a group situation, where several individuals have created their own models and the analyst now wishes to combine them to produce an aggregate model. The analyst can also merge concepts. Suppose there are two very similar concepts in the aggregate model; the analyst can make concept A incorporate all the links that connect to concept B, and then remove concept B, i.e., merge concept B into concept A (e.g., COPE>M18=19 merges concept 19 into concept 18). There is also an additional facility to merge ranges of concepts. Merging creates, especially in a group situation, some links and connections between separate models. This may, for example, allow individuals to see how policies they suggest, based on their own views, may have different ramifications in terms of other views of the situation. If the group "own" and feel committed to the combined map then it can become a powerful aid to sharing understanding, and simulating effects of policies.

Autogrouping

This facility enables the analyst to create a group by identifying crucial concepts that the client feels represent the core of an issue.

Typing the command COPE>G5$10 creates a Group 5 based upon the key concept 10. With a number of groups created in this way, an algorithm is used to add to each group concepts that are linked closely to the key concept.

Grouping with the Subsystem

In essence the subsystem is a part of the model (a list of concepts) that the analyst can build up in a number of ways. The operation of the subsystem follows simliar logic to the MAP command, where if the analyst types SUB before a List or Explore command, the concepts referred to in that command will be placed in the subsystem. Thus, for example, the analyst might type SUB followed by L"HOUSING," which would add all concepts containing the word HOUSING into the subsystem. There is a facility to transfer the contents of the subsystem to a group.

Loop Identification

In some instance the existence of feedback loops within the causal chain of belief is a significant aspect of the data for the client. These are similar to feedback loops as described in Systems Dynamics literature, although they are more related to idiosyncratic expression of belief. There is within COPE a facility to search for, identify, and print out these loops so that they be examined more systematically if required.

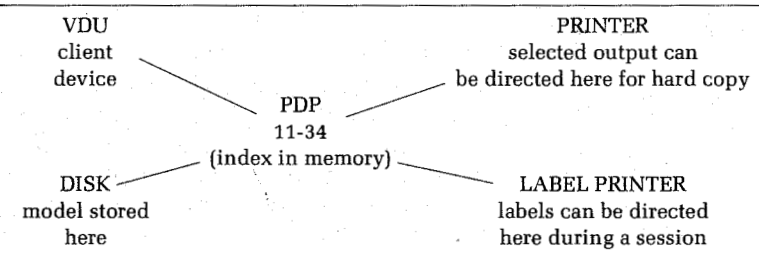
Summary

In this paper we have attempted to describe a simulation model that is based upon well-established theories of cognition and yet at the same time has been constructed as an effective experiential learning device grounded in the needs of a client or client group. While there are clear implications within the modeling method for the simulation of cognition we do not regard this aspect to be as significant as the practical learning or operational gaming aspects of the work. As the appendix below indicates, the computer software is suitable for use on computers that are widely available and we believe that as it is more widely used more applications will become apparent.

Needless to say we are continually identifying new requirements that need to be incorporated in the software package. We are currently working on a method for involving the client group in the construction of a System Dynamics [25] simulation model by designing a slow and careful process for moving from a COPE model representing qualitative beliefs to a structure of quantitative beliefs. Our experience [7] suggests that a process of this sort can maintain the client's interest and lead to a significantly higher probability of implementation of the suggestions that are derived from a simulation model. In addition we are extending the software so that cognitive maps can be drawn on a graph plotter and represented on an interactive refresh graphics screen.

Appendix

COPE—System Layout

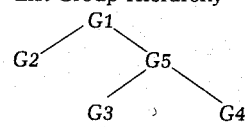


Technical Details

Hardware	—COPE runs on a PDP 11-34 with twin 5-megabyte cartridge disks.
Operating system	—RSX-11M
Software	—COPE is programmed in some 6000 lines of FORTRAN, comprising 55 subroutines, which are overlayed to run in 32 Kw
Capacity	—COPE can handle up to 600 concepts, 800 signed relationships, 200 connotative links and 80 groups

Appendix 2 Below some of the commands for exploring the model are illustrated using the model described in Fig. 1. The computer print-out shows briefly a typical way in which a model may be explored. More complex commands such as Merging and Autogrouping are not included.

```
>COPE                                SUPER COPE          08-JAN-80

COPE>USE HELEN
MODEL FOR HELEN GREAVES                                  —Model title
XXXXXXXXXXXXXXXXXXXXXXXX

COPE>LG                                                  —List Groups
G1  DOING A GOOD JOB
G2  ATTITUDE TO IRESS
G3  POLITICAL FACTORS
G4  APPROACH TO TENANTS
G5  EFFECTIVE WORKING RELATIONSHIPS
COPE>LH                                                  —List Head concepts (those with no
                                                          consequences)
16  Success as Chief Officer
COPE>LGH                                                 —List Group Hierarchy
G1  ; G2
G1  ; G5
G5  ; G3
G5  ; G4
COPE>LGC5                                                —List Group Contents for concept 5
G5  EFFECTIVE WORKING RELATIONSHIPS

GROUPS:
G3  POLITICAL FACTORS                                    subordinate groups are listed
G4  APPROACH TO TENANTS

CONCEPTS:
5  /Attempt/Do not attempt/to inform tenants individually of
      what doing
8  /Favorable/Less favorable/attitude of members

COPE>LOOP                                                —check for feedback LOOPS

LOOP 1        LENGTH 4        POSITIVE                   loop 1 is positive and contains four
                                                          concepts and works in the following
                                                          manner
+8    Favorable/Less favorable attitude of members
-14   Time taken up by committee
-12   Not spending enough time because of pressure of week
        by week things
+11   Getting information disseminated, favorably reported
        in press and inls
+8    Favorable/Less favorable attitude of members

     8  14  12  11

8    0  -1   0   0                                        matrix for loop 1 is given
14   0   0   1   0
12   0   0   0  -1
11   1   0   0   0
```



LOOP 2 LENGTH 2 POSITIVE
+15 Favorable/Unfavorable reactions of tenants expressed to members
+L1 POSITIVE LOOP 1 LENGTH 4
+15 Favorable/Unfavorable reactions of tenants expressed to members

15 L1

15 0 1
L1 1 0

loop 2 consists of loop 1 with the addition of concept 15

COPE>

COPE>X8
8 Favorable attitude of members can be explained by
–3 a decrease in Backlog in setting things done . . . which may be because
1 In some areas the situation has been bad for a long time

—explore the explanations and consequences for the positive pole of concept 8

8 Favorable attitude of members can be explained by
2 Float policy informally for prior discussion

and/or can be explained by
6 Try to indirectly assess individual opinions and attitudes

and/or can be explained by
7 an increase in support of committee chairman . . . (K)

K indicates concept 7 is connotatively linked to other concept(s)

and/or can be explained by
11 . .an increase in getting information disseminated, favorably reported in press and inls . . .

and/or can be explained by
15 . .Favorable reactions of tenants expressed to members

8 Favorable attitude of member can lead to
–14 a decrease in time taken up by committee which can lead to
–12 NOT XX Not spending enough time because of pressure of week by week things XX

and/or can lead to
9 . .an increase in likelihood of proposals being accepted which can lead to
16 an increase in success as Chief Officer

COPE>K7
7 Support of committee chairman is linked to
4 /Do/Don't/deal swiftly, efficiently, sympathetically, with people's problem

—list the connotative links to concept 7

COPE>C2,16
2 Float policy informally for prior discussion can lead to
8 . .Favorable attitude of members . . . which can lead to
9 . .an increase in likelihood of proposals being accepted which can lead to
16 an increase in success as Chief Officer

—trace the path(s) of concepts that provide an explanation for the consequences of concept 2 for concept 16

References

1. Abelson, R. P., The Structure of Belief Systems, in *Computer Models of Thought and Language* (R. C. Schank and K. M. Colby, Eds.). Freeman: San Francisco, 1973.
2. Colby, K. M., Simulation of Belief Systems, in *Computer Models of Thought and Language* (R. C. Schank and K. M. Colby, Eds.). Freeman: San Francisco, 1973.
3. Weizenbaum, J., *Computer Power and Human Reason*. Freeman: San Francisco, 1975.
4. Muller-Reissman, K., and Rechenman, F., Cognitive Systems Analysis, in *Concepts and Tools of Computer-assisted Policy Analysis*, (H. Bossel, Ed.). Basel: Birkhauser, 1977.
5. Kelly, G. *The Psychology of Personal Constructs*. Norton: New York, 1955.
6. Eden, C., Jones, S., and Sims, D., *Thinking in Organisations*. London: Macmillan, 1979.
7. Eden, C. and Jones, S., Publish of Perish?—A Case Study, *Journal of the Operational Research Society* 31:131–139 (1980).
8. Eden, C., and Sims, D., Computerized Vicarious Experience: The Future for Management Induction? *Personnel Review*, forthcoming (1980).
9. Eden, C., Jones, S., Sims, D., and Smithin, T., Intersubjective Issues and Issues of Intersubjectivity, *Journal of Management Studies*, forthcoming (1980).
10. Sims, D., and Jones, S., "Making Problem Definition Explicit in Teams," Working Paper: University of Bath, 1980.
11. Eden, C., "Participating in Decisions," Working Paper: University of Bath, 1979.
12. Mckinnon, R. Personal and Situational Variables in Organisation Communication Load M.Sc. Thesis: University of Bath, 1979.
13. Jones, S., "Analysing Qualitative Market Research Data," Working Paper: University of Bath, 1980.
14. Wittgenstein, L., *Philosophical Investigations*. Oxford University Press: Oxford, 1953.
15. Sims, D., Eden, C., and Jones, S., "Facilitating Problem Defintion in Teams," *European Journal of Operational Research*, forthcoming (1980).
16. Morimoto, K., Notes on the context for learning, *Harvard Educational Review* 43:245–257 (1973).
17. Cohen, G., *The Psychology of Cognition*. London: Academic Press, 1977.
18. Eden, C., and Smithin, T., Operational Gaming in Action Research, European *Journal of Operational Research* 3:450–458 (1979).
19. Wrightson, M. T., The Documentary Coding Method in *Structure of Decision* (R. Axelrod, Ed.). Princeton University Press: Princeton, N.J.
20. Holsti, O., "Operational Code Belief Systems: a code book" Duke University North Carolina, 1976.
21. Rokeach, M., *The Nature of Human Values*. Free Press: New York, 1973.
22. COPE, Pocket Reference Guide School of Management: University of Bath, 1979.
23. COPE, Users' Guide School of Management: University of Bath, 1979.
24. Strobel, M. G., and Bossel, H., Matching Man and Model in *Concepts and Tools of Computer-Assisted Policy Analysis*. (H. Bossel, Ed.). Birkhauser: Basel, 1977.
25. Coyle, R. G., *Management System Dynamics*. Wiley: London, 1977.