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ABSTRACT

This paper begins with a description of the context and background of cognitive research into knowledge acquisition and representation for computer based training. The nature of concept maps is alluded to and examples are given of the ways that maps can facilitate knowledge elicitation. It is noted that: (1) the concept knowledge in this research is acquired and reported by a hypertext system called NoteCards; (2) NoteCards is used as a pre-processor to computer based training applications, and the metaphorical structure created by NoteCards and displayed to browsers is used in hypertext navigation; and (3) visual examples of concepts are held on a videodisc attached to the workstation that runs NoteCards. It is concluded that NoteCards provides a useful environment for experimenting with knowledge elicitation and providing a trainee/learner-based interrupt interface to computer based training. The six figures provided include concept maps, an equipment layout diagram, and a hypertext explanation and video picture. (19 references) (Author/EW)

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From Concept Maps to Computer Based Learning: the experience of NoteCards

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Abstract

The paper starts with a description of the context and background to cognitive research in into knowledge acquisition and representation for CBT Aberdeen. The nature of concept maps is alluded to and examples are given of the way maps can facilitate knowledge elicitation. The concept knowledge is acquired and reported in this research by a hypertext system called NoteCards. NoteCards is used as a pre-processor to computer based training applications. The metaphorical NET structure created by NoteCards and displayed in browsers is used in hypertext navigation. Visual examples of concepts are held on a videodisc attached to the workstation that runs NoteCards(NC). The paper concludes that NoteCards is a useful environment for

a) experimenting with knowledge elicitation; and
b)providing a trainee/ learner based interrupt interface to computer based training.

Introduction

The research reported in this paper is concerned with the way graphical representations of knowledge can facilitate its elicitation and use in computer based learning training.

The graphical representation used is the concept map.

This paper is arranged as follows:

1. Background
2. Concept Maps: some definitions
3. Eliciting Knowledge
4. Concept Types and Link Types
5. Explanations
6. Styles of Interaction

Research into concept maps and human cognition provide the main background to this research. In Aberdeen we have chosen to call this research "Knowledge and Information Mapping" (KIM). The UK Government initiative to promote leading edge technology with computers called the Alvey programme has given the academic/ commercial focus with which the work was undertaken. The Alvey programme brought together four partners into a collaborative research project called Intelligent Interface for Integrated Knowledge Systems. In this research ,workers in the University of Aberdeen have been contributing cognitive research.[1] Overall the project is aiming to build a series of demonstrators of different aspects of intelligent computer based authoring and learning. To this end we have specified a rich technical environment for the author and learner. Included are videodisc pictures, touch screen and tablets along with more traditional pointing devices (eg mouse). The "workstation" consists of two computers. A knowledge station (Xerox 1186) and a CBT station (Amiga 2000) with the possibility of other computers on a Local Area Network.

Figure 1 about here

The cognitive research in the project is concerned with two themes; first, exploring the usefulness of the Concept Map metaphor of knowledge representation. Secondly, building an adaptive modeliing system that can help knowledge engineer, CBT designer and learner. This paper concentrates on the concept mapwork.

Concept Maps

No attempt will be made to explain the concept map here. A number of well referenced sources trace the development and theory. (See for example McAleese (1987a %definitions[2]); Novak & Gowin D B. (1984 %authoritative source); Donald (1984 %research evidence); Hannabuss (1986 %review of literature); Pask (1984 %related research; Tatsuoka, 1986 %related theory); and Stewart, J (1980 % related research). As such the present author's understanding of the phenomenon is derived from many sources. Central to the idea of the concept map (CM) is the "metaphor" of the CM. Indeed to speak of a CM is to use a metaphor. [3]The idea of the net metaphor [4]is one of the strong features of recent constructivist cognitive research. The metaphor is used in this research in two ways. First as a way of helping the domain expert "give up their secrets" [5] By allowing the expert to see in graphical format the concepts and the link relationships it is postulated that this further unlocks the experts'domain expertise. The following example of a concept map comes from a domain area, Social Skills.

Figure 2 about here

In recent trials Duncan (1988 %research review %project document) suggests that this technique causes difficulties for some experts. Experts do not naturally find a schematic and graphic representation helpful. However the map has a place in extracting the experts' horizon (see below) It is argued that when a expert is presented with a map they can see that there may be other concepts which can be included.

Second, the map can be used as a representation device to show the "terrain" and "street" views of what has to be learned in terms of concepts and relationships. (McAleese, 1987c %opinion) Such maps show knowledge that can be learned and suggest routes through that knowledge. (see below) This paper now examines ways in which maps can help elicitation.

Knowledge Elicitation

This aspect of the work is still developing and here a tentative report is made. In order to capture domain knowledge NoteCards (NC) , a LISP based package developed at Xerox PARC, is being used. At the beginning of the research a graphical representation system was required. NC was chosen as it gives a very friendly interface when producing concept maps. In making this choice we acknowledged that there has to be a two computer workstation. Although this may seem clumsy there are a number of advantages. The main advantage is that the Knowledge Elicitation computer can act as a knowledge file server for a local area network. As indicated above, an Ethernet (LAN), links the Delivery and Design computer (ie Amiga 2000) to the knowledge workstation. In practice knowledge engineering work, design work and learning can all be taking place at the same time using this "Co-operative Authoring and Learning Environment" The designer, using the Amiga, the domain expert using the Xerox and the learner (perhaps using a different delivery computer) share common domain knowledge.

NoteCards: Basically NC uses a series of editors available on the Xerox 1186 workstation. (see Trigg et al , 1987 %further detail) The principal package for this research is Grapher which can compute nodes and links and produce a series of tree and forest browsers. In addition NC was designed as an extensible system and it has been developed in Aberdeen with Minder (Prior (1987 %project document) and in PARC and elsewhere with layers such as Instructional Design Environment (IDE). These enhancements give the user a variety of tools to use in producing complex hypertext knowledge systems.

In Aberdeen we are still developing the protocols for elicitation. Essentially there are two main phases to the process. First an initial phase when the expert is allowed to express himself in a familiar and comfortable way. He is encouraged to talk about a topic and to record a series of concept statements. Such statements usually consist of pairs of nodes with a single link.

eg {anger} is-a(n) {emotion}

Such statements are then put into NC using the tools of Minder and IDE. As a result, the concepts and links can be portrayed in one or more browsers. Further, the concepts are classified into two or more broad classes; eg [Factors], [Activities], [Procedures]. In addition the link types are classified and "tuned" in order to identify synonyms and similar links types that are formed by different parts of speech; eg[is-a] and [are] are taken to be the same.

The **second phase** of the work uses one or more of the following three strategies.

1. Graphic: The NC system constructs a browser from any specified node (ie {**concept**}). Grapher permits any combination of link types to be included and allows up to an infinite number of levels of links to be followed. That is starting with a node and a set of link types, NC computes and displays all nodes and links up to, say, four links removed from the starting node.

Figure 3 about here

Different types of network can be computed. Grapher, *at present*, has a number of default settings which result in tree and forest structures.

2. Concept Categories: As a result of the classification of the concepts into classes (eg [Factors]) the expert is presented with a series of templates for that concept class. Such templates are basically different card types in NC. Each card type can have associated with it different properties; such as standard link types and different icons for display in browsers.

Figure 4a about here

Essentially each concept class can be thought on as a filing box of concepts of that type; that is a generic concept type. The stimulus that produces more concepts for the expert is the concept class. The attached NC figures are examples of the concept class template [Factors].

Figure 4b about here

3. Link Types: The domain expert is presented with a series of blank nodes and a set of suggested link types. Such link types are accumulating from the current research and from others (eg Donald, Fisher et al). The stimulus that produces more concepts for the expert is the **link type.**

In practice initial research work with a social skills expert indicates that elicitation using all three types of strategy is most successful. All three strategies lead to "capturing" and structuring of knowledge in a form which can be displayed in browsers and can be used in the CBT applications. (see Duncan (1988) %corroboration) The display of knowledge in browsers is still a very difficult matter. Both "**terrain**" and "**street**" views of the concepts and their links are necessary. (see McAleese (1987a) %corroboration)

Knowledge elicitation work is really designing a system that can help in the automatic elicitation of knowledge. It appears from our work so far, that experts need help in arranging their knowledge for concept map representation. However, when an "incomplete map" is presented it is easy for the expert to "spot" inconsistencies or incompleteness. It is suggested that the metaphor of the net is a much more powerful tool in recording domain expertise than the RULE in an expert system.

For example, an expert shell might require a domain expert to make the rule:

IF [*client*] presents-with problem
OR IF [*client*] shows dependency
OR [*client*] shows anxiety
THEN use {***empathy***}

Different Link Types: Knowledge elicited in such a system is not confined to semantic knowledge. It includes Design Knowledge and Pedagogic Knowledge as well. Given the co-operative type of system described, it is possible for a CBT designer to augment the domain expert's maps using another set of link types. ("Designer" Links) For example a designer can examine a map such as the one above and augment the links with links to visual exemplars of the concepts.

Figure 5 about here

Here the designer is using a link type "is-exemplified" to produce a hyper-structure that contains the semantic links and CBT control links as well. The above map shows t the concept {**questioning**} is exemplified in video example 34/5 as is the concept {**anger**}. This additional layer of design link types is important when styles of interaction are considered. A further type of links can be achieved using "**Pedagogic**" or sequencing links. For example the designer, in consultation with the expert, may decide that there exists some hierarchy of concepts in terms of learning or performance objectives. Using links such as "requires-an-understanding-of" "subsumes" or "leads-on-to" the designer can order concepts. At a later stage in the process, the learner might ask "**What can I learn next?**" the sequencing links make it possible for the total system to suggest a learning path given a starting node.

Concept Types and Links

In order to manage the complexity of knowledge a system of fitting concepts for different domain areas into broad concept classes has been attempted. (see above) An initial classification in the soft skills area of social skills was to suggest that the expert used three concept classes. Factors, Activities and Procedures.[7] In other words if one examines the concepts "given up" by the expert, one can fit them into one or other of these broad classes. In a similar way the number of link types is being limited. Clearly the classification and constraining of concept classes and Link Types is the most difficult and value laden aspect of cognitive research. We are attempting to strike a balance between the unbridled use of link types and a restrictive set that may confine the domain experts. It is only fair to report that this area of research is themost difficult and is unlikely to be resolved until a may experts have provided their domain expertise. Work in Davis by Kathleen Fisher et al is providing useful parallels. (Fisher K et al (1987 %corroboration %detail)

Explanations

In using concept maps to display knowledge one is attempting to "explain" what a concept is without resorting to a syntactic structure such as the English language. Essentially the map is an explanation in graphical form. Just as it is possible to say: "*Empathy is a type of emotion as is anger. It requires feelings and intentions. Empathy is a social skill in the same way as questioning is a social skill.*" So the concept map above is a graphic representation or "explanation" of this understanding. The ability to share and elicit understandings using concept maps is one of their strengths. More work will have to be undertaken to determine the exact way maps facilitate communication and elicitation. Problems exist in particular with concepts that are linked in multi-link clusters. That is where three or more nodes (concepts) are linked by one link label.

Styles of Interaction

To bring the threads of the argument together it is necessary to look at the way learners might interact with a CBT system. In general there are a wide variety of styles of interaction. Such styles can be grouped into four broad categories.

1. **Didactic** (*Teach me about ...*)
2. **Encyclopedic** (*Tell me about...*)
3. **Dictionary** (*What is a....*)
4. **Simulation** (*What would happen if...*)[8]

The over-arching feature of the styles is the locus of control. Computer based (Didactic) or Learner based (Encyclopedic, Dictionary and Simulation). Any of the styles of learning can apply to a learner at any time or to different learners at any time during CBT sessions. A learner might start in Style 1 (didactic), change to Style 3 (dictionary) and return to Style 1. Whereas another learner, learning about the same topic might start in Style 3, move to Style 1 and continue in Style 4 (simulation).The concept map is central to supporting a learner in making such changes.[9] Consider now an example of an interaction scenario. The learner in this example is an industrial trainee learning about negotiating skills.[10] Seated at his workstation he chooses to learn about "Empathising with ones clients". In particular this is about the concept {empathy}. The learner first chooses to be taught about the concept of empathy using a didactic style. That is the CBT system acts very much like a teacher who presents information, gives examples and tests, from time to time, if the learner is able to correctly meet performance objectives by answering test items. At any time the learner can interrupt the didactic mode. In this example suppose the learner is watching some video material of a consultation. The video is a visual example of "Achieving empathy with a client"

Figure 6 about here

Using the mouse the learner points to the client and stops the video. He is presented with a Dialog Window that offers him a number of alternatives. For example;

1. **Explain** {*empathy*}[11]

2. **Define** {*empathy*}

3. **Show other examples of** {*empathy*}

4. **Show that would happen if the Negotiator exhibited** {*anger*}/ {*aloofness*}

5. **See a concept map with** {*empathy*} **as the nodal concept.**

Suppose the learner choose Option 2. He would see in a Dialog Window a definition of {Empathy}. (See Figure 6)

The definition is a hypertext description. The concepts that the system knows about (ie concepts in the knowledge base) are highlighted. By pointing at one or more of these terms the learner can navigate around a complex set of descriptions of the concept {empathy}. If on the other hand the learner had chosen to see a concept map of {empathy} he would in effect see the hidden hyper-structure (showing concepts and links) that underpins the definition.[12]

So Far

The above example is a very brief scenario designed to highlight the way in which concept maps can and are being integrated into CBT. In this example the knowledge elicitedusing NoteCards and stored in the knowledge base of the CBT system is being used to help the learner navigate the learning system and give graphical and text explanations of concepts. The concept map is not only a pictorial representation of the nature of knowledge it is a cognitive manager. The nodes and different link types provide the syntactical units for directing learners through a complex learning system using different learning styles. NC has so far provided a very useful environment in which to explore the use of concept maps for CBT. Problems of course exist. LISP on the Xerox 1186 is not a very fast system. It is geared to network use and therefore local disc access can be slow. Further the mixture of different operating systems over the LAN is not efficient. When the functionality of NC is available on the Amiga 2000 then the justification for the LISP machine will be less. It is likely that with more homogeneity over the LAN will speed up its operation. This will be essential when the system is extended to take in Wide Area Networks over large geographical areas.

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Ray McAleese is a member of a team working on the Intelligent Interface for Integrated Knowledge Systems Project. This is a collaborative project between Aberdeen University, Convergent Systems Ltd, Logica plc and the National Physical Laboratory and part funded under the Alvey Programme.

Biography

Ray McAleese is Director of the University Teaching Centre, University of Aberdeen. He has written on aspects of information systems, instructional design, staff development cognitive issues in authoring and innovation.

Footnotes

[1] University of Aberdeen; Logica plc; Convergent Systems and the National Physical Laboratory

[2] All citations in this paper are QUALIFIED in line with research carried out by Duncan & McAleese (1982 %detail %historical development). Qualified citations are akin to labelled link values between concepts (authors) As such the present author's interest in concept maps derives in part from citation patterns.

[3] Recent research on neural networks is an attractive source of psychobiological corroboration. It is too early to suggest that triggering of neural nodes in cognitive processing is more than an interesting parallel. No analogy exists as yet. (see Petersen (1988 %research evidence; Anderson (1988 %opinion); Johnson-Laird (1987 %opinion) and Hinton (1987 %research) A further and related metaphor is suggested by connectionist or "parallel" computing (Hills W D (1985 %corroboration))

[4] That is nodes and links are similar to knots and links in a net.

[5] A term used by a former member of our team, Anne Martin, to describe knowledge elicitation (Martin (1987 %research survey)

[6] himself= him/herself

[7] Clearly theses generic concept classes apply at this stage to ONE domain area only. Evidence is mounting that such concept classes apply across domain areas. For example from social skills to domestic science and engineering applications.

[8] Four styles identified by Derek Shanks, a colleague who is working on the construction and evaluation of a videodisc training programme on Social Skills.

[9] Another feature is the modelling procedures that builds up profiles and overlays of the learner, the task and the workstation environment. This feature is NOT considered in this paper.

[10] The arguments would apply to any knowledge domain, procedural or declarative.

[11] The concept in curly brackets { } is the concept that the visual example is about. Using Gordon Pask's terminology the topic that is "aimed at". (Pask, 1984 %definitions %explanations) Note, a visual example may be used to demonstrate more than one concept. The interrupt system should generate the appropriate "fill" for this slot as it

"knows" about the visual example from a video description database.

[12] At present (March 1988) this must be achieved by using the Xerox 1186 screen. It is intended that very soon the data on which browsers are computed will be made available to the Designer or Learner computer. At this stage both screens can be seen by the user; in due course they may be some distance remote from each other over a Local Area Network.

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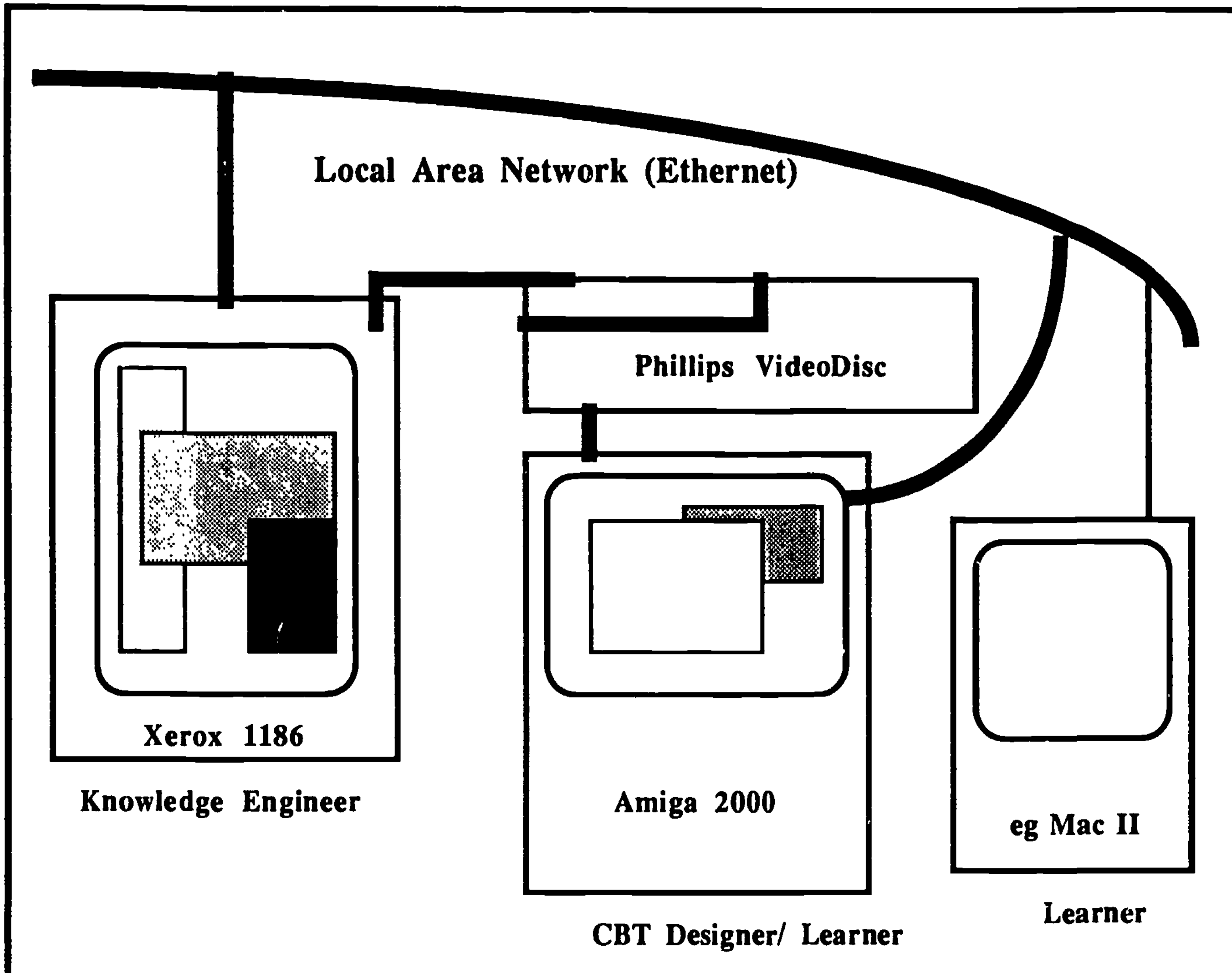

Figure 1 Equipment Layout

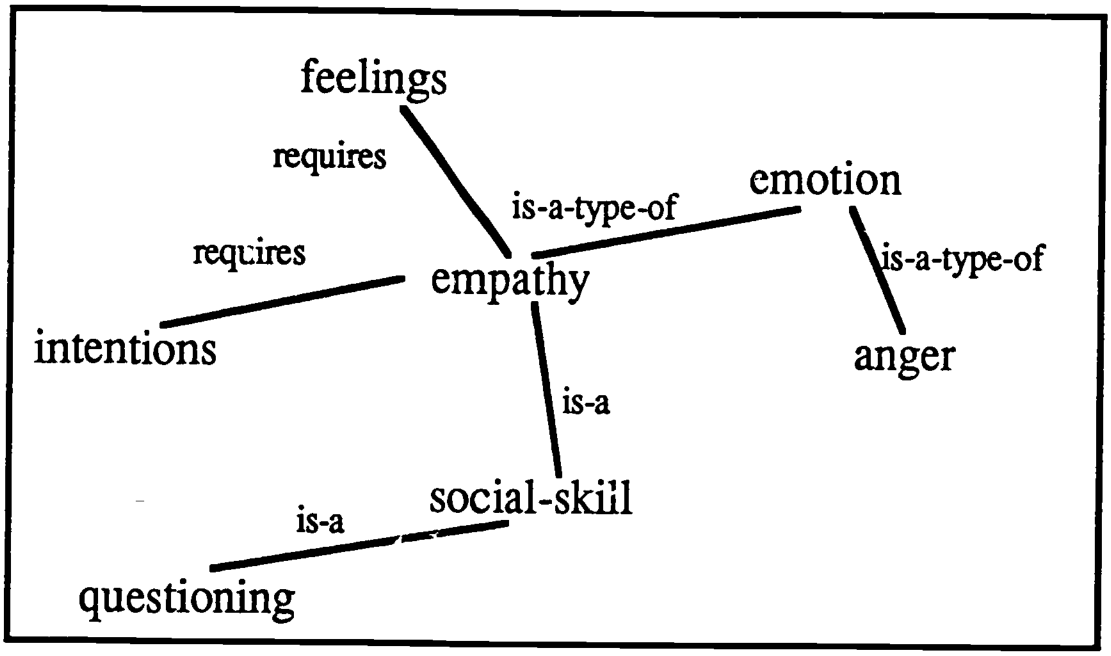

Figure 2 Social Skills Concept Map

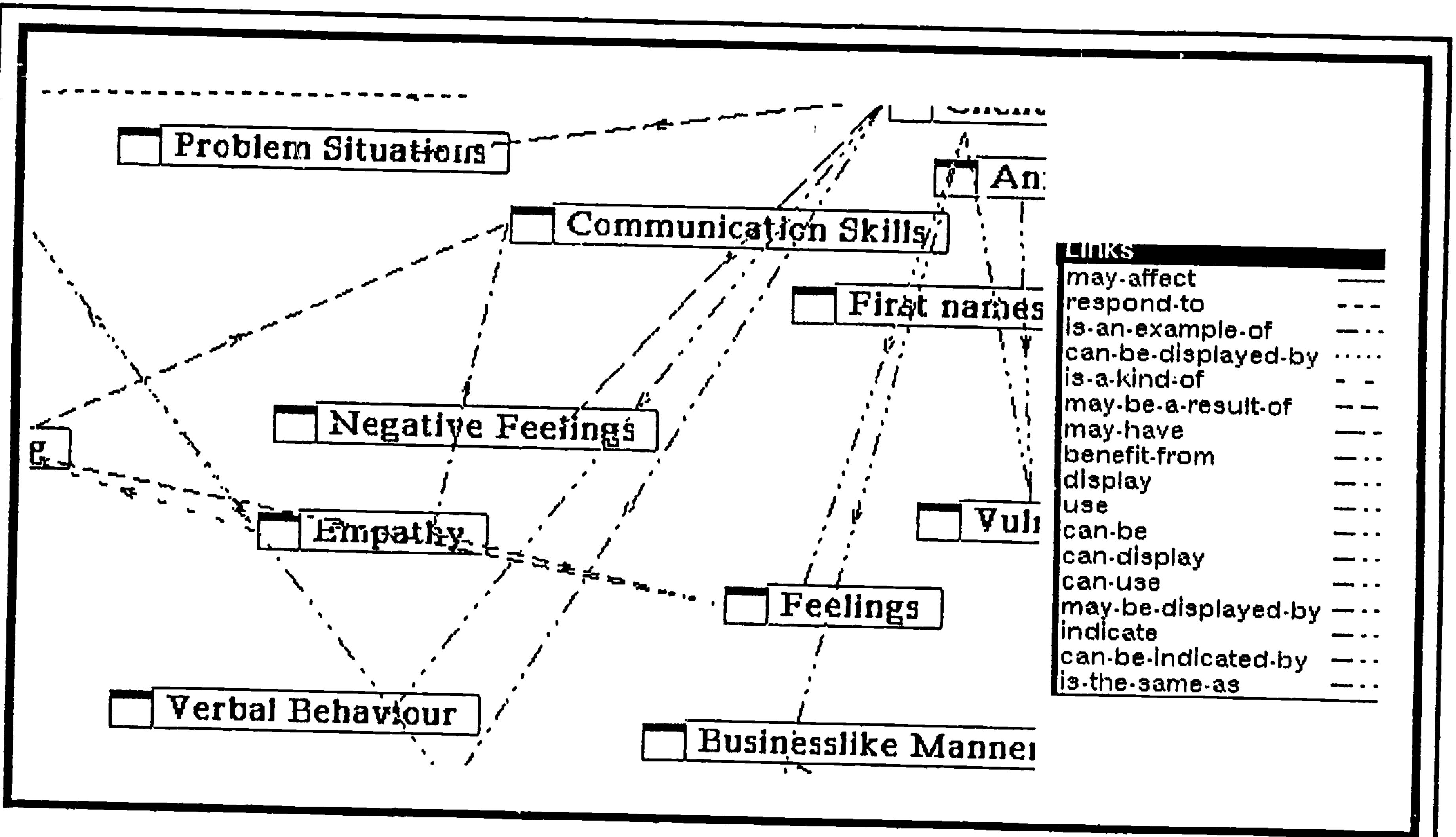

Figure 3 Concept map
Computed by NoteCards
(BitMap Snap from Xerox Window)

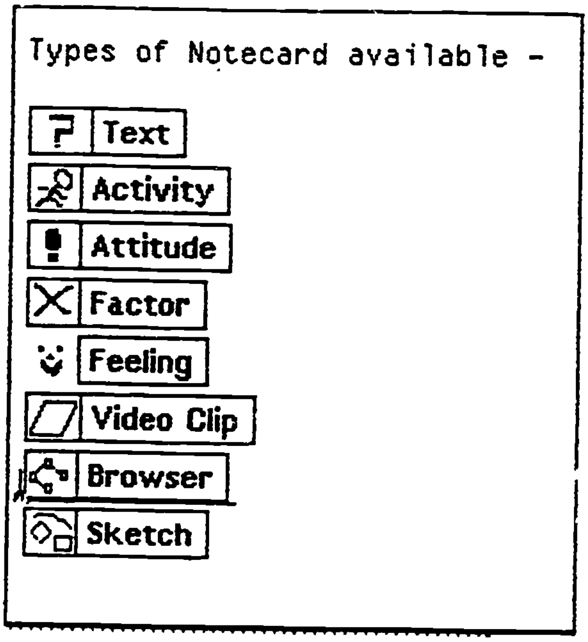

Figure 4a Types of Concept Class and Examples of Icons used

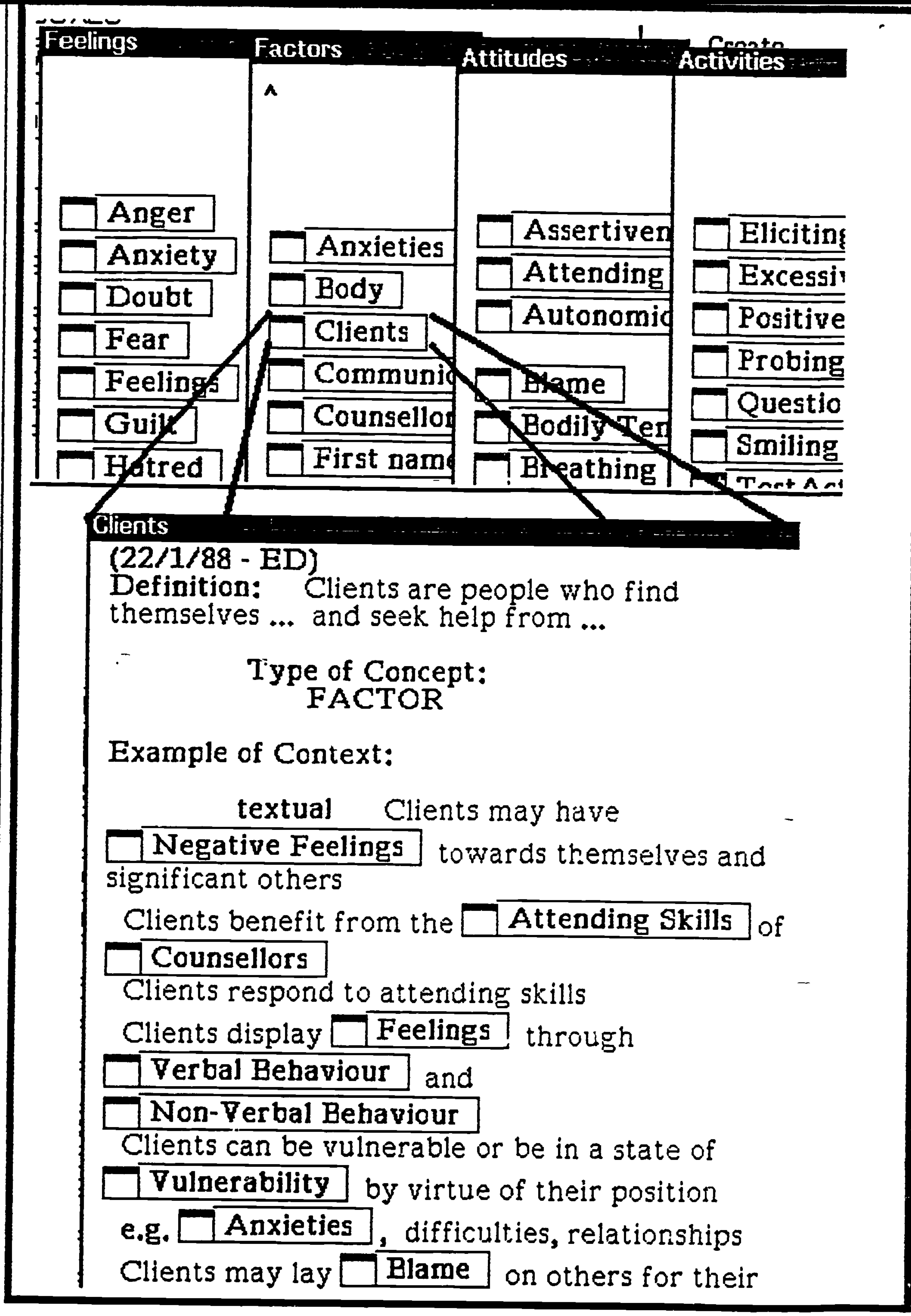

Figure 4 b Concept Class "FACTORS"
with other classes and one
instance of the class {Clients}

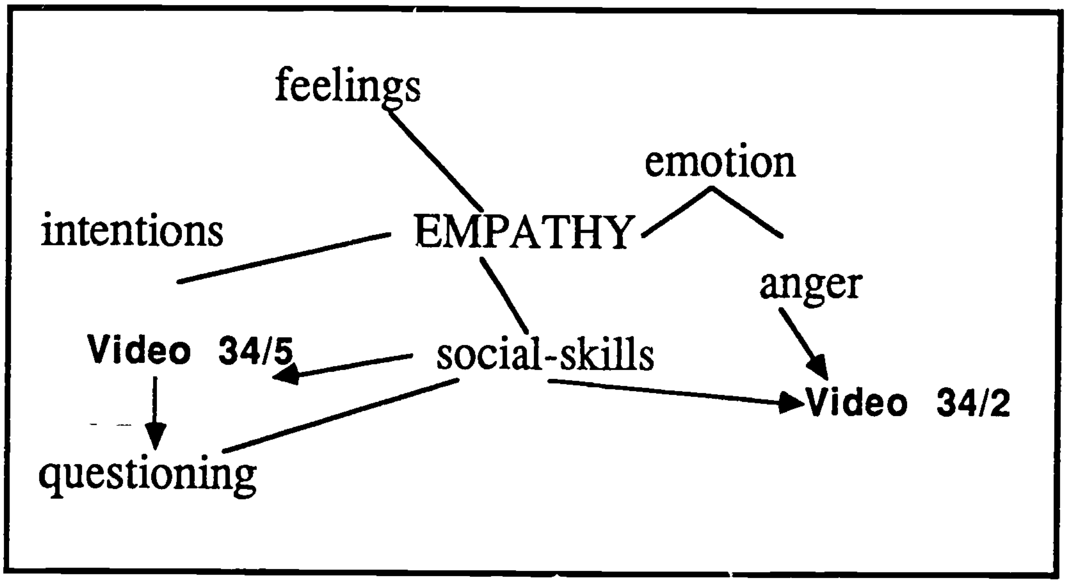

Figure 5 Concept Map with "designer Links"

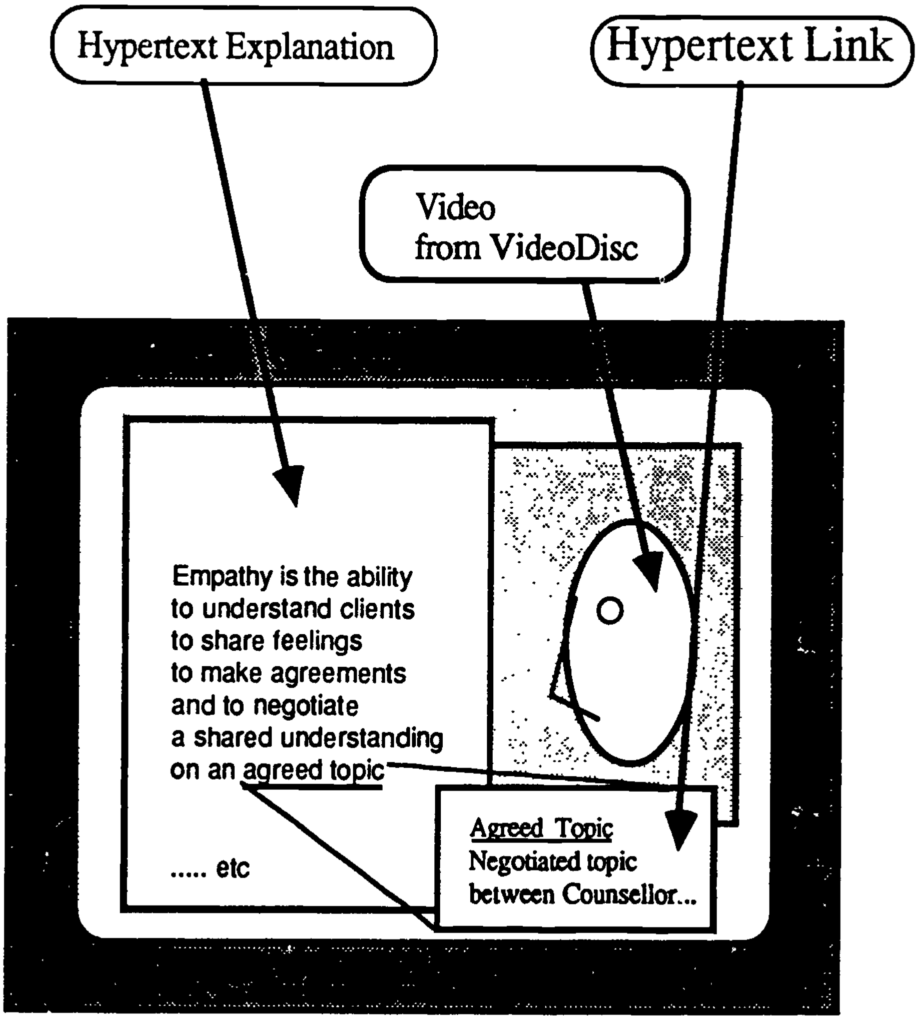

Figure 6 Hypertext Explanation and Video Picture