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# Issues affecting the utility of computer-based mapping applications

Peter E.H. Smee B.Sc. M.Sc.

Author number: M708 5180  
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in Educational Technology  
at the Institute of Educational Technology,  
The Open University,  
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# Abstract

This thesis records an investigation of the issues that affect the utility of computer-based mapping applications - where a computer-based mapping application provides a computer-generated environment to facilitate the construction of concept maps. 'Concept map' is a term used to describe a graphical representation, the purpose of which is to informally express ideas and the associations between ideas, whilst facilitating the generation and sorting of ideas.

The work reported is the first of its kind to compare and contrast the strengths and weaknesses of the different media with which concept maps can be constructed. The work is exploratory, combining investigation with software development.

A brief overview of the content of the work completed is as follows:

- The literature relating to concept mapping was reviewed to identify the *likely* needs of those engaged in mapping activities.
- A significant sample of people was surveyed in order to ascertain the *perceived* needs of those engaged in mapping.
- The software currently available to draw maps was surveyed in order to assess the utility of computer-based mapping applications, with respect to the perceived needs of mappers.
- A prototype computer-based mapping application was developed to act as a focus for mappers' comments.
- As a result of feedback from users of the prototype computer-based mapping application, it was discovered that the main way in which people create maps is to generate and sort a few ideas at a time.
- The prototype software was further developed, as a result of feedback from mappers, and in its final form has been made available in the public domain.

- A glossary of terms was developed, by which the designers and users of computer-based mapping applications can assess the utility of any given piece of software, in the light of the tasks mappers wish to achieve.

# Acknowledgements

I would like to express my thanks to Tim O'Shea and Clive Lawless for their guidance, support and encouragement - and for the confidence they have shown in my work.

Thanks are also due to: Louise Smee, Richard Ennals, Robin Mason, Bob Zimmer, Peter Whalley and Pat Fung, who have all taken the time to read and comment on my work; to all those who have given me feedback on KwikSort, BrainBox and HyperMap - helping me to improve the design of the software and remove bugs from the implementation (without their input, many of the ideas developed within this PhD would not have reached their present form); and to Pauline Adams, Di Mason, Hansa Solanki, and Olwyn Wilson for their help when I had administrative problems.

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# Chapter One

## Introduction

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# 1.1 Aims

The aim of this thesis is to investigate the issues which affect the utility of computer-based mapping applications - where *a computer-based mapping application is an application designed to facilitate the construction of concept maps.*

In this thesis, the term *concept map* is used to describe *a graphical representation, the purpose of which is to externalise ideas and associations generated from within the mind of the mapper, without requiring the mapper to explicitly define those ideas and associations. The concept map acts as a graphical aide-memoir. Ideas are expressed briefly and succinctly - using words, phrases, or short sentences. Associations are expressed by clustering related ideas and linking important ideas - using lines and/or arrows. (See Figs 1.2 to 1.10 for examples).*

The decision to focus on the construction of concept maps, rather than the construction of other kinds of graphical representation, such as flow diagrams or semantic nets, was taken in the light of a literature review. The review indicated that the simplicity of the *concept map design* provides an efficient way in which to balance (1) the need for a *mapping product* capable of expressing ideas and relationships between ideas, with (2) the need for a *mapping process* in which ideas can be generated and sorted with minimal effort.

The work reported is the first of its kind to investigate the strengths and weaknesses of different mapping media, and to explore how computer technology can be used to complement and/or replace existing media.

The conclusion of the investigation is that a computer-based mapping application provides a powerful set of tools for those who wish to construct concept maps. The conclusion is based upon the findings of the investigation, which were as follows:

- The construction of a concept map is best achieved by utilising the following two-stage process:
  - *A technique known as concept sorting is used to generate and sort ideas.* The result of the concept sorting session, known as a *concept sort*, is then used as the basis for the concept map.
  - *Lines and/or arrows are added to the concept sort.* The lines and arrows more explicitly express what is in the mapper's mind. By expressing what is in the mapper's mind more explicitly, lines and arrows reduce the ambiguity which might otherwise arise when the mapper refers back to his or her map at a later date - and reduce the confusion which might arise should the map be presented to others.
- To accomplish the two-stage process (outlined above), it is necessary for the concept map to be constructed within a *dynamic medium*. A dynamic medium is a medium in which editing can be achieved with a minimum of effort. *A computer-based environment is able to provide a suitable dynamic environment.* Computer software can be developed which *facilitates the processes of generating and sorting ideas* - and then *facilitates the addition of lines and arrows, once the sorting process has been completed.*

To arrive at the conclusion outlined above, the following work was conducted:

- There was a review of the literature related to concept mapping to identify the *likely needs* of those engaged in mapping activities.
- A significant sample of people was surveyed to ascertain the *perceived needs* of those engaged in concept mapping.
- The software currently available to draw concept maps was surveyed to assess the utility of computer-based mapping applications, with respect to the *perceived needs* of mappers.

- A prototype computer-based mapping application was developed to act as a focus for mappers' comments.
- As a result of feedback from users of the prototype computer-based mapping application, it was confirmed that the main way in which people create maps is to generate and sort a few ideas at a time.
- The prototype software developed as a result of feedback from mappers was implemented in final form and made available in the public domain.
- A glossary of terms was developed, by which the designers and users of computer-based mapping applications might assess the utility of any given piece of software, in relation to a given mapping goal.

## 1.2 Concept sorts and concept maps

To understand the key arguments within this thesis, it is essential that the *process* involved in constructing a map be differentiated from the *product* resulting from that process.

Concept sorting (a process) gives rise to a concept sort (a product). The concept sort is then edited (a process) to become a concept map (a product). To ensure that no ambiguity remains, the following text:

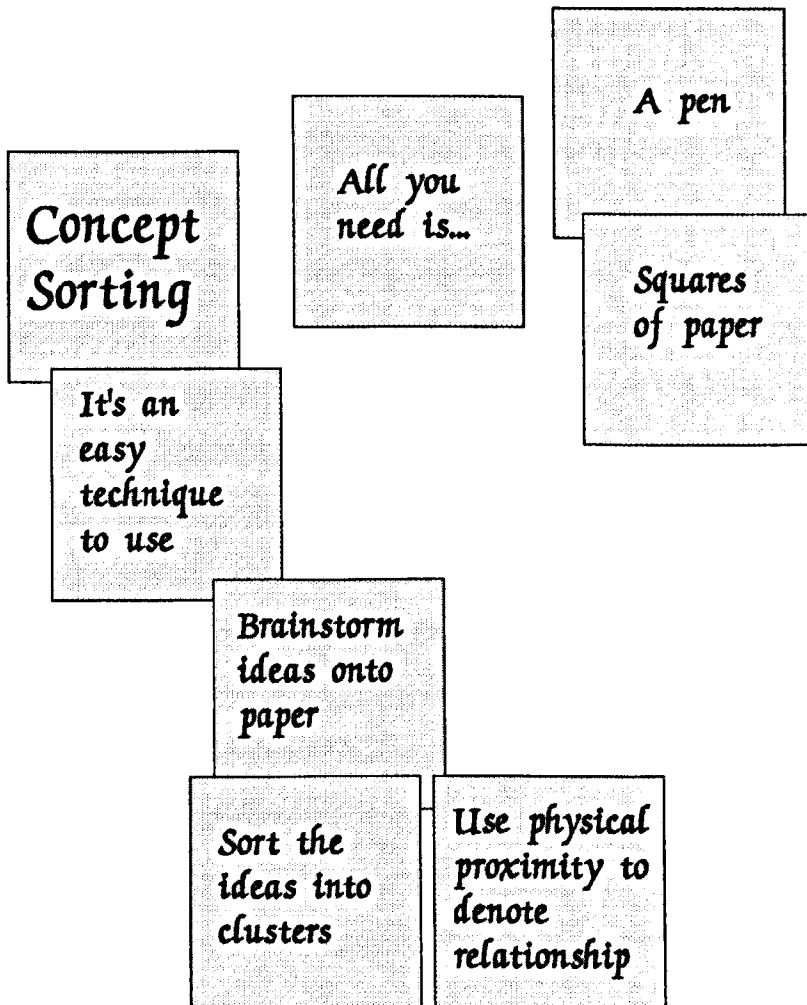
- describes the concept sorting process.
- clarifies the manner in which a concept sort must be edited to become a concept map.

Traditionally, concept sorting has been achieved by writing ideas on small squares of paper. The squares are then moved around a work surface, until the ideas which are most closely associated are clustered together in a form 'meaningful' to the mapper. Normally, ideas are clustered so that physical proximity denotes strength of relationship. Once in a form meaningful to the mapper, the concept sort is complete (see Fig 1.1).

If the concept sort is to be kept for future reference, the concept sort is converted into a concept map. The conversion process requires the squares of paper to be stuck to the work surface and links (lines and/or arrows) to be drawn to emphasise important relationships. An example of the conversion process is presented in Fig 1.2. Other examples are presented in Fig 1.3 to 1.10.

As may be seen, a concept map consists of *ideas* (represented in the form of short pieces of text - normally words, phrases or short sentences) and *relationships* between ideas (represented by proximity on the map and by the use of lines and/or arrows). *Lines* indicate that some kind of logical relationship exists. *Arrows* indicate a measure of directionality. For example, an arrow can indicate one idea leading to another, as in the case *heat* leads to *thirst*.

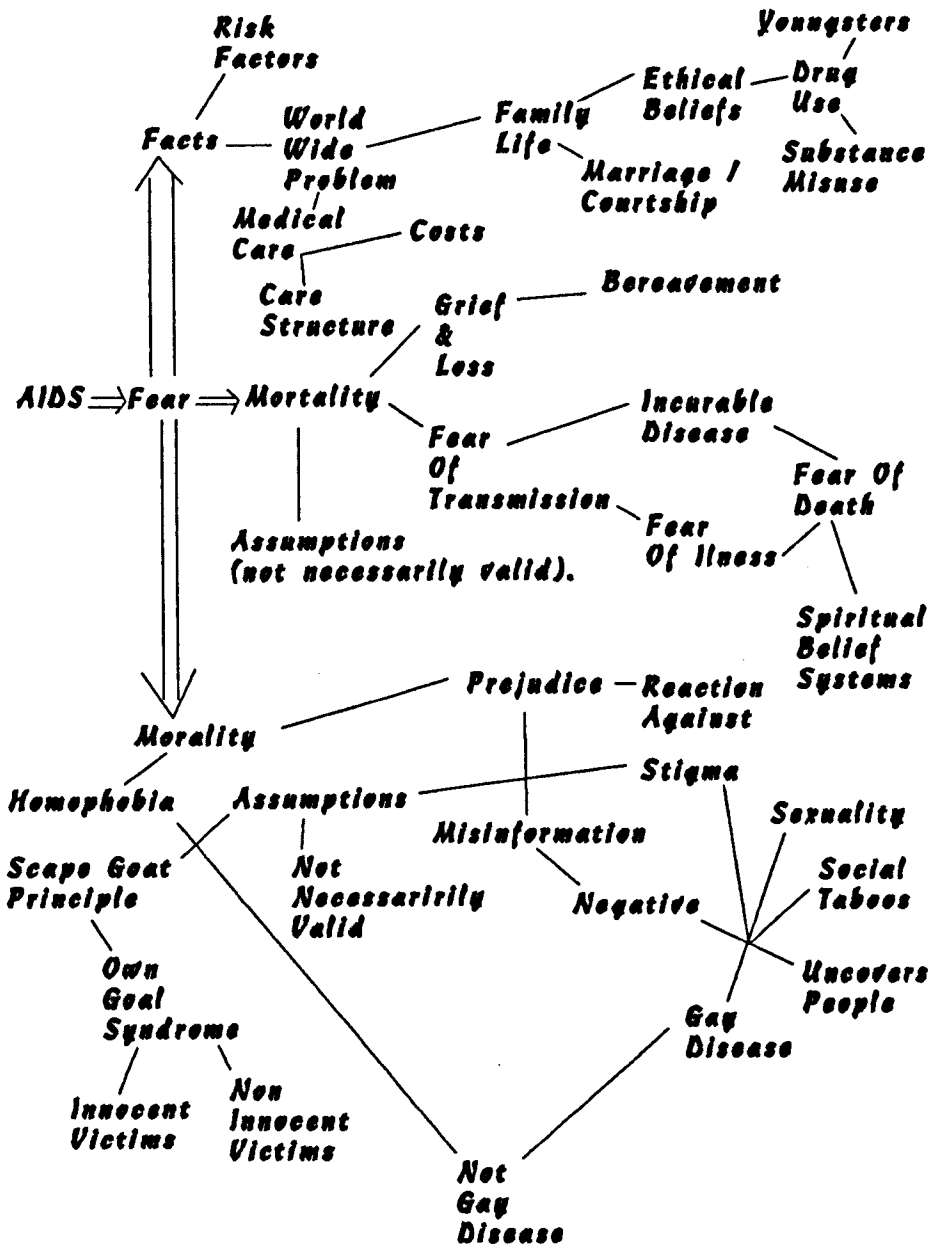
Fig 1.1: A concept sort conducted using Post-It notes



**Note:** This figure provides an example of a *concept sort* resulting from the process of *concept sorting*. Starting with the central idea 'Concept Sorting' other ideas are brainstormed onto separate Post-It Notes. These notes are then arranged so that those ideas which are most closely related are placed next to one another. Ideas can be added or subtracted from the map at any time.

**Fig 1.2: An example of a concept sort which was later converted into a concept map (Smee 1988)**

*(NB: This concept sort was drawn to focus a knowledge elicitation session. The spatial positioning of ideas was used as an aide-memoir, rather than a formal representation of concepts and relationships. Lines were then added to express relationships between ideas more explicitly).*



Note: Having completed a concept sort, it is possible to draw lines on that concept sort to turn the concept sort into a concept map. Drawing lines on the concept sort helps to make relationships more explicit, which is useful if the map is to be read by others, or is to be referred to at a later date.



## 1.3 Thesis structure

Chapter 2 reviews the literature relating to concept maps. The chapter introduces a number of terms, which enable different aspects of the mapping process to be classified using the headings:

- mapping goals - an exploration of the reasons why people draw maps,
- mapping needs - an exploration of the needs related to the mapping process,
- map designs - a review of the different kinds of map it is possible to draw,
- mapping media - a review of the tools with which people construct maps.

The conclusion of chapter 2 is that the majority of mapping goals are associated with the clarification of a personal mental model of the focus subject domain, rather than with the production of a physical artefact. Given that the mapper is using the mapping process as a form of mental scaffolding, it is proposed that the utility of a computer-based mapping application is dependent upon the ease with which ideas can be generated and sorted, rather than upon the sophistication of the presentation tools provided.

Chapter 3 reviews the five main mapping applications available at the commencement of the project in 1992. For the purpose of this thesis, a computer-based mapping application is considered to be an application which provides the facilities necessary to concept sort and concept map with minimal effort. The five applications reviewed are: ABC FlowCharter 1.13, C.K.Modeller, gIBIS, MindMaps Plus and SemNet.

The conclusion of the review of computer-based mapping applications is that currently available mapping applications provide a wide range of *presentational* tools, making complex map designs possible to draw, but that the applications reviewed do little to facilitate the *process* of generating and sorting ideas - two main problems being that too much of the work space is taken up with menu bars and tool bars and too many mouse clicks are required to add and edit ideas.

Chapter 4 describes a software development methodology known as the Adaptive Waterfall Model for Knowledge Acquisition. Chapter 4 also introduces KwikSort, a prototype mapping application, constructed using the Adaptive Waterfall methodology.

KwikSort was used to elicit user feedback. User feedback was then used to improve the design of KwikSort and to provide a focus for more refined feedback. The outcomes desired from using the Adaptive Waterfall Model were:

- an understanding of the issues affecting the utility of computer-based mapping applications;
- the design for a computer-based mapping application which the majority of mappers questioned would find useful; and,
- a checklist which might be used to assess the utility of computer-based mapping application designs.

Chapter 5 presents the feedback provided by KwikSort users. Each of the five iterations of the software is described in detail, with screen shots. At the end of the chapter there is a graphical depiction of each system. The depiction enables the reader to make a quick comparison between the facilities each system provides.

Chapter 6 summarises the feedback offered during structured interviews with twenty-one users of KwikSort Version 5. The summary demonstrates the various ways in which different users reacted to KwikSort; and makes it apparent that there are common themes running through these different reactions. The chapter then presents a set of tables to highlight the common themes running through the feedback given in the structured interviews. The themes coalesce into two kinds:

- The first feedback theme indicates that a mapper's reaction towards computer-based mapping depends upon whether that mapper utilises an *organic protocol* (adding and sorting a few ideas at a time), or utilises a *disclosure protocol* (preparing ideas and

associations in the mind's eye, prior to externalising those ideas and associations before they are lost from working memory).

- The second feedback theme indicates that there is a core set of six process-based facilities which mappers utilising an organic protocol find useful - if they are to be able to generate and sort ideas with a minimum of effort.

Chapter 7 discusses the experimental results and outlines a set of initial conclusions based on those results, taking into account the limitations which the methodology imposed on the experiment. The chapter combines all the work reported in this thesis, to summarise what has been learned about the issues affecting the utility of computer-based mapping applications (CBMA). This summary is presented in the form of the CBMA-Checklist, which enables the user to identify his or her own mapping needs and then to assess the utility of computer-based mapping applications with respect to these needs. The checklist is used to design and implement a new Windows-based mapping application called BrainBox (and its Macintosh cousin HyperMap) - with the aim of providing future researchers and users with the tools to evaluate the ideas and observations made in the course of this text.

In chapter 8, a final set of conclusions is provided - these conclusions being that for most mapping goals it is essential for a computer-based mapping application to have a core set of process-based tools, because most mappers who would want to use a computer-based mapping application work organically (adding and sorting a few ideas at a time). Beyond this core set of process-based tools, a more complex set of process-based tools is useful if there are a large number of ideas to be sorted, and a simple set of presentational tools is also useful if the mapper requires to print out maps to give to others. Overall, the evidence is that complex sets of presentational tools are only of use to a minority of mappers who have to produce complex formal maps, such as flow diagrams, for distribution to others. Along with these conclusions is a set of suggestions for ways in

which the work reported in this thesis might be used as the starting point for future research.

## 1.4 Glossary

During the course of this text, many new terms are introduced. The following glossary outlines some of these terms. A fuller glossary may be found in **Appendix 2**.

Term	Definition
<b>Mapping protocol</b>	The protocol mappers utilise when constructing maps
<b>Disclosure protocol</b>	...refers to the process of creating a set of mental associations, and then externalising those associations before they are lost from working memory. <i>(The evidence analysed in this thesis indicates that only a minority of maps are constructed using a disclosure protocol).</i>
<b>Organic protocol</b>	...refers to the process of generating and sorting ideas in a cyclical process. <i>(The evidence analysed in this thesis indicates that most maps are constructed organically).</i>
<b>Step protocol</b>	...refers to the process of downloading ideas from an external source (such as a database) before sorting those ideas in an organic fashion. <i>(The evidence analysed in this thesis did not suggest that anyone utilises step protocol, only that step protocol might become possible as more information becomes increasingly available in electronic form).</i>
<b>Mapping goals</b>	Mappers' motivations for drawing maps
<b>Descriptive goals</b>	...refers to the desire to model a subject domain in a precise and unambiguous manner - for example, to lead an engineer through the process of repairing some complex machinery.
<b>Feedback goals</b>	...refers to the desire to investigate a student's level of understanding - for example, to ascertain whether someone has understood what they have been taught..
<b>Knowledge goals</b>	...refers to the desire to integrate ideas from a number of sources - for example to draw together notes from a number of lectures.
<b>Overview goals</b>	...refers to the desire to communicate an overview - for example, to provide a map as a summary of a presentation.
<b>Preparation goals</b>	...refers to the desire to clarify and edit an outline for a written or oral presentation.
<b>Problem goals</b>	...refers to the desire to model a problem - for example, to explore the issues which might arise in a merger between two companies.
<b>Recall goals</b>	...refers to the desire to imprint information into memory and provide a visual stimulus to aid recall of that information - for example, constructing a map can be an effective way in which to prepare for an exam.
<b>Solution goals</b>	...refers to the desire to model a solution and the possible implications of that solution - for example, to model the effect upon the economy of raising interest rates.
<b>Warm-up goals</b>	...refers to the desire to explore how much students already know about a subject which they are about to be taught.

*(Continued overleaf...)*

<b>Mapping media</b>	The tools the mapper uses to enable the mapping process
<b>Computer-based</b>	...refers to the use of a computer in order to facilitate the process of generating and sorting ideas.
<b>Move &amp; stick</b>	...refers to the traditional concept-sorting protocol in which ideas are written on pieces of paper (or plastic) and then sorted on a table top (or magnetic board).
<b>Write &amp; wipe</b>	...refers to the use of a blackboard or whiteboard, onto which the mapper draws his or her map.
<b>Write once</b>	...refers to the use of paper, onto which the mapper draws his or her map.
<b>Map designs</b>	The different classifications devised in order to <i>compare</i> the design of concept maps with alternative map designs
<b>Formal maps</b> <i>(Maps whose design is significantly more complex than that of a concept map)</i>	Formal maps model a subject domain with 'dictionary-like' accuracy. Formal designs are the pictorial equivalent to formal logic and therefore require ideas and relationships to be represented more explicitly and more accurately, than required when a mapper is constructing a concept map. Examples of formal maps are flow diagrams and semantic nets. The main difference between formal maps and concept maps is that formal maps take much longer to construct because of the level of detail and accuracy required.
<b>Informal maps</b> <i>(Maps whose design is of 'equivalent' complexity to that of a concept map)</i>	Informal maps are named thus because aspects of the subject domain being modelled are represented implicitly - the map being used as an aide-memoir, rather than a detailed description. Concept maps are the simplest kind of informal map. Other forms of informal map include causal maps and Buzan maps. It is the simple nature of the concept maps, which underlies the decision of this thesis to propose that a concept map is the best trade-off between explicitly modelling a subject and the need to minimise the effort required in the modelling process.
<b>Spatial maps</b> <i>(Maps whose design is less complex than that of a concept map)</i>	A spatial map is one in which relationships between ideas are represented by clustering ideas, so that those ideas which are related are placed physically near to one another on the work surface. Spatial mapping protocols, such as concept sorting, are foundational in the construction of other map designs. Providing work is conducted in a dynamic medium, the easiest way in which to produce a formal or an informal map is to first construct a spatial map. Having constructed a spatial map, the mapper can then edit that map into an appropriate form. It is the foundational nature of spatial maps which underlies the decision of this thesis to propose that concept maps be developed using the following two-stage process: (1) use the <i>process</i> of concept sorting to <i>produce</i> a concept sort, (2) edit the concept sort into the form of a concept map.
<b>Template maps</b> <i>(Maps whose design is significantly more constrained than that of a concept map)</i>	Template designs may be split into two categories - <b>simple</b> and <b>complex</b> . A simple template map provides the user with blank spaces, which prompt the mapper to think of ideas to write in those spaces. Complex template maps, in addition to prompting the mapper with blank spaces, also prompt the mapper to use a structured mapping protocol. An example of a complex template map is Soft System Methodology. Examples of simple template maps are causal chains and force field diagrams.

(Continued overleaf)

<b>Software facilities</b>	The kinds of facilities which facilitate the construction of concept maps by supporting the process of generating and sorting ideas, and then facilitate the process of editing the resultant concept sort into the form of a concept map.
<b>Arrow links</b>	...refers to the facility to draw links with arrowheads on them. If the link can be moved, it is described as <b>dynamic</b> . If the link cannot be moved, then it is referred to as <b>static</b> .
<b>AutoWrite</b>	...refers to the facility by which a mapper can list the ideas on a given map or text pad and, with a single mouse click, copy those ideas to any other map or text pad.
<b>Custom zoom</b>	...refers to an ability to customise the amount of zoom used when viewing a map surface.
<b>Easy input</b>	...refers to the ability to input ideas with a single mouse click or key stroke.
<b>Expand function</b>	...refers to a facility which enables a mapper to capture a single idea on one map and make that idea the central idea on a new map.
<b>Export text</b>	...refers to any facility which enables the mapper to collate ideas from one or more maps in the form of a list, which can be exported to a word processor.
<b>Ideas boxes</b>	...refers to a text field in which the user can type an idea. Ideas boxes which can be moved are described as <b>dynamic</b> . Ideas boxes which cannot be moved are described as <b>static</b> .
<b>Ideas pad</b>	...refers to a facility which helps users generate ideas - for example by utilising creative thinking techniques, such as those devised by Edward DeBono.
<b>Line links</b>	...refers to the facility to draw a line between two ideas. If the link can be moved, it is described as <b>dynamic</b> . If the link cannot be moved, then it is referred to as <b>static</b> .

## 1.5 Clarification

To clarify how the terms introduced in the preceding glossary might be utilised, the following 'generic' sentence is offered:

### **People can use...**

- write-once media
- write & wipe media
- move & stick media
- computer-based media

### **...in order to produce...**

- spatial maps
- informal maps (especially concept maps)
- formal maps
- template maps

### **...to achieve...**

- warm-up goals
- knowledge goals
- feedback goals
- recall goals
- problem goals
- solution goals
- preparation goals
- overview goals
- descriptive goals

### **...using a...**

- disclosure protocol
- organic protocol
- step protocol



## **1.6 Visual overview**

The maps presented on the following eight pages present an overview of the work completed during the course of this thesis. The maps were drawn using the computer-based mapping application BrainBox.

# Issues affecting the utility of computer-based mapping applications

There are nine motivations which might spur someone to generate and sort ideas pictorially. These motivations are termed "mapping goals".

The nine motivations are: warm up goals, knowledge goals, feedback goals, recall goals, problem goals, solution goals, preparation goals, overview goals, description goals.

Most mapping goals are best attained through the use of a dynamic medium and through the use of an informal map design. On the basis of this observation, it can be argued that most mapping goals are best achieved using concept sorting to generate and sort ideas (clarify thoughts), before then converting the resultant concept sort into the form of a concept map.

Mapping products can be classified into four design types. The four design types are: spatial designs, informal designs, formal designs, and templates.

Ideally, computer-based mapping applications should provide users with a small number of dynamic elements.

The media which support the MAPPING PROCESS can be classified into four basic types. The four types of media are: write once, write and wipe, move & stick and computer-based.

Maps: It should be possible to link related maps together, so that the holistic aspect of the domain being mapped does not get lost in a confusion of detail.

Although an application with little workspace and lots of tools may enable the mapper to produce maps of great presentational quality, most mapping goals are concerned less with the map as a product, and more with mapping as a process (a form of mental scaffolding). Thus, for many people it is likely that a workspace optimised for product will be less attractive than a workspace optimised for process.

Ideas boxes: ideas boxes are text fields in which ideas text is displayed. Ideas boxes should be dynamic - that is, it should be possible to move ideas boxes around the map surface.

Ideas text: it should be possible to input, edit, and/or export text with a minimum of effort.

In addition, mapping applications need to take into account the restrictions posed by the standard use of 14" or 15" monitors. Mapping applications need to minimise the space taken up by tool bars and menus. The point being made is that if there is insufficient workspace for the mapper to brainstorm onto, the mapping application will become a hindrance, rather than a help, to the mapping process.

Lines: it should be possible to move the lines (or arrows) which connect ideas boxes, in order to reflect changes in the user's perceptions regarding the underlying structure of the subject domain.

There should be tools which allow ideas text to be manipulated in both list and graphical form, and which support the generation of ideas.

# Available systems

In late 1992, there were three important commercial mapping applications and three mapping applications devised to aid research into computer based mapping. By 1994, there were at least twelve available systems.

Although some of the research has suggested that generating and sorting ideas in a computer based environment is a useful aid to thought, very little has been written about the kinds of tools which would facilitate these two process.

Most of the commercial systems have focused on the map "as a final product", often aiming their marketing at the business community, who may need to draw flow diagrams or organisational diagrams representing the chain of command within an organisation.

Commercial apps in 1992: ABC FlowCharter, CK Modeller and Mind Map Plus.

Research apps in 1992: COPE, gIBIS and SemNet.

Recent apps: Corel Flow, ChartsNow, InfoMap, MagnaCharter, RF Flow, SnapGrafx, Visio.

The focus of the available systems on PRODUCT (rather than PROCESS) suggests that while current mapping applications might favour the construction of a quality PRODUCT, they do not facilitate the PROCESS of generating and sorting ideas. Current applications do not tend to fully support the use of the mapping process as a form of mental scaffolding, and therefore fail to adequately support many mapping goals.

On the positive side: most applications provide tools to: (1) edit, cut, copy, and paste blocks of text; (2) enable ideas boxes to be moved around a map surface; (3) enable ideas boxes to be copied and pasted between maps; (4) enable links to be drawn and edited; (5) enable a number of linked maps to be stored within a single file.

On the negative side, much of the screen space is taken up by tools and menus, which restricts the workspace, and makes it difficult to maintain an overview of the subject domain being mapped (on a 14"/15" monitor). In addition, charting applications often provide an unnecessary level of complexity for the many mappers who: (1) have a low level of computer literacy, (2) require a very simple level of functionality, and (3) are liable to be intimidated by the thought of learning a major new package.

Importantly, only some of the applications reviewed here had any support for the manipulation of ideas in a list format (c.f. COPE, InfoMap and ABC FlowCharter). Most had no support at all. It was difficult for mappers to convert lists of ideas into text in ideas boxes, or to convert text in ideas boxes into lists. Both these omissions limited the potential of the mapping applications reviewed and increased the effort required to use those applications.

# Development of experimental protocol

There is no research literature relating methods of generating and sorting ideas within in a computer based environment.

Analysis indicates that current mapping applications are focused on PRODUCT, rather than PROCESS, suggesting that current applications miss many opportunities to aid the would-be mapper

Given the limitations of the mapping applications available in 1992, when this study commenced, and given that it was not possible at that time to write add-on modules to extend the functionality of a given mapping application, it was decided to develop a new mapping application, using the PLUS programming language (PLUS PPL). Using PLUS it was planned to develop a very simple mapping application based on concept sorting, and to add functionality in response to user feedback.

There is: (1) a lack of tools for manipulating ideas text, other than as a graphical object;(2) too much screen space is taken up by toolbars and menubars; and, (3) many applications provide much more functionality than is needed, resulting in an unnecessary level of complexity for naive users.

The new mapping application was called KwikSort, and the development and feedback process was divided into two stages.

Then, secondly, a fuller testing phase, in which having responded to user feedback (in as far as the PLUS PPL allowed), each user was interviewed in depth about their perceptions of computer based mapping in general and KwikSort in particular, and asked about the facilities they would like to see added to KwikSort in future versions.

Finally, the results of the interviews were collated and used to design a new computer based mapping application called BrainBox.

By providing a physical expression of the feedback gleaned from KwikSort users, BrainBox aims to: (1) raise the profile of computer based mapping; (2) enable more mappers to use computer based mapping by providing them with working software; and, (3) to provide a focus for discussion amongst those who design commercial charting and graphics applications, such as ABC FlowCharter and Visio.

An initial development stage, where the basic system was demonstrated / used by a growing number of users, and during which time the major bugs and design flaws were ironed out.

This development phase also provided a time in which the author was able to get better acquainted with the needs of individual users, and to develop further awareness with which to devise a structured interview, to be used to obtain more formal feedback.

**Initial development and testing**

The two aims of the initial development phase were to: (1) identify and rectify major design errors; and, (2) develop enough understanding of how mappers use computer based mapping to develop a more formal line of enquiry.

**Context**

The overall aim of the KwiSort study was to ascertain the kinds of facilities mappers would like programmed into computer based mapping software.

**Plan**

- To create a simple application based on concept sorting, in such a way that the resulting concept sort might be edited into the form of a concept map.
- To gain INFORMAL USER FEEDBACK.
- To adapt the user interface, and/or to add facilities in response to user feedback.

**Rationale**

**Theoretical**

There was a need to develop an understanding of how mappers use computer based mapping applications, before it would be possible to devise a formal interview structure, which might effectively capture users' views.

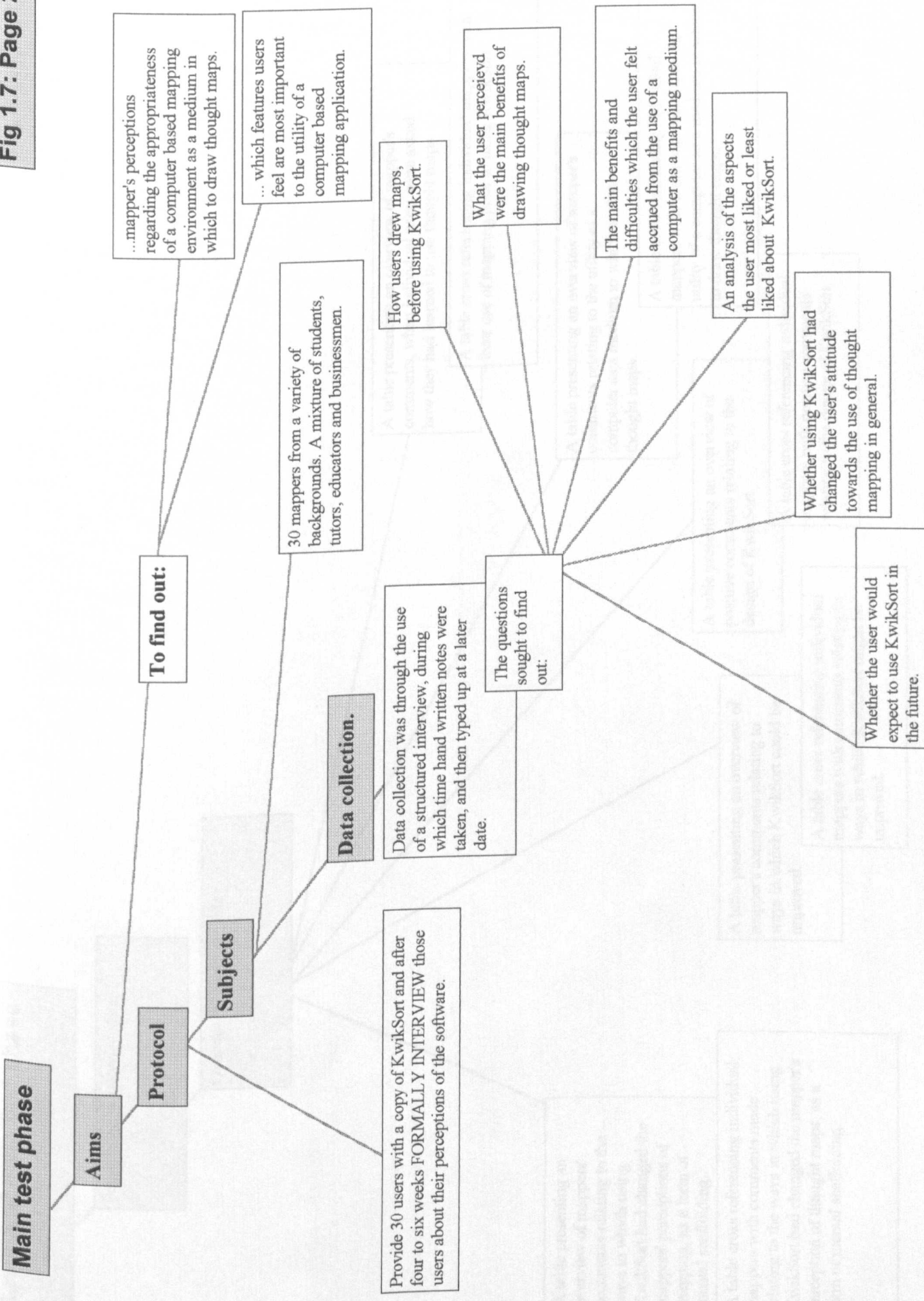
**Practical**

Informal feedback enabled KwiSort to develop in response to users' comments. This enabled KwiSort to increasingly reflect the perceived needs of a number of users, rather than simply reflect the ideas of the system designer...

Many users who showed an interest in testing KwiSort were busy people, who did not have time to test a half formed piece of software. When the users wanted to use KwiSort, they wanted to use it to draw 'working maps', not 'toy maps'. By requesting INFORMAL FEEDBACK, during the initial development phase, the impact on user's time was minimised, enabling more users to participate in the test program.

... which reflects the idea that effective software should be human centred, responding to user needs, rather than being imposed by software designers.

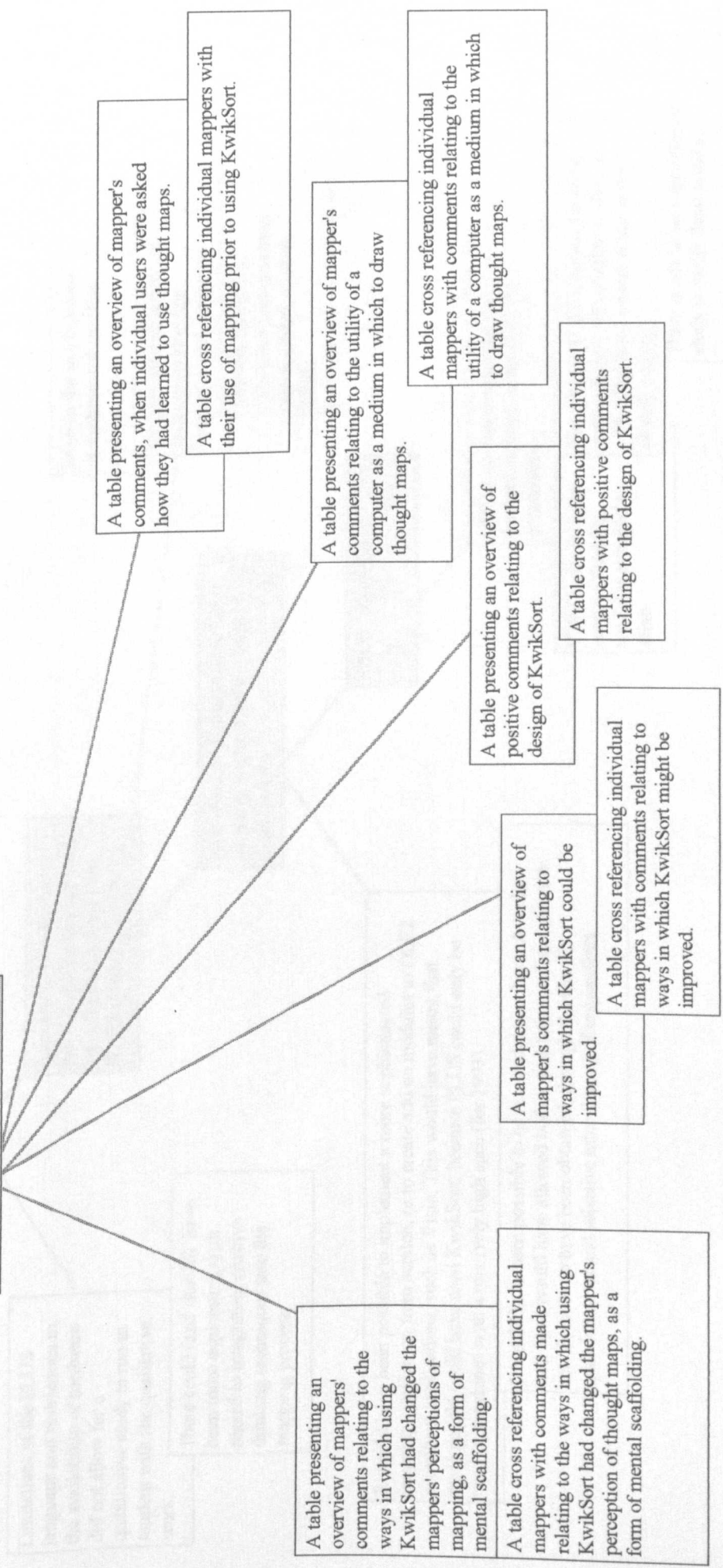
Fig 1.7: Page 21



# Results of main test phase

Presentation of interview data

Overview of interview data



**Conclusions**

INITIAL conclusions based on the results obtained in interviews with KwikSort users.

Experimental limitations, and how these might affect the initial conclusions.

Limitations of the PLUS language and restrictions in the availability of hardware did not allow for a quantitative study to run in tandem with the qualitative work.

There could (and should) have been more exploration with regard to integrating creative thinking techniques into the mapping process.

It would have been possible to implement a more sophisticated mapping application from scratch, or to create add on modules to OLE2 compliant applications, such as Visio. This would have meant that more people could have used KwikSort, because PLUS could only be used on machines with a relatively high spec (for 1993).

It would have been possible to have a wider user base. A wider user base would have allowed both a qualitative and quantitative set of results to have been obtained, through the use of questionnaires and selective interviewing of respondents.

A review of how computer based mapping has changed since the beginning of the KwikSort study (in 1992).

How changes in computer based mapping might affect the initial conclusions.

FINAL conclusions.

An effective CBMA should contain the following six features (as a minimum): (1) some kind of NotePad, on which to store ideas, (2) some kind of AutoWrite facility to convert between map based and block text, (3) some kind of expand function, which allows related maps to be held in the same file; (4) an A4 workspace; (5) dynamic ideas boxes; and (6) dynamic links

Discuss the implications of sophisticated charting tools, such as Visio.

Discuss the availability of faster programming languages and computers.

Discuss changes in Windows programming environment, such as OLE2

CBMA should contain the six features outlined in the INITIAL conclusions.

CBMA should have creative thinking modules attached to them.

The advent of OLE2 allows charting applications to have features, such as a NotePad to be added, if one is not already present

There needs to be a quantitative study to verify these results.



# BrainBox - a CBMA based on experimental conclusions

A checklist of facilities, which enhance the utility of a CBMA

Using the checklist to develop a CBMA called BrainBox.

The checklist will be of use to mappers thinking of buying a CBMA; or programmers developing a CBMA, who want to identify the goals for which CBMA's are used and the facilities which enable mappers to achieve those goals.

Description of the design

Mixture of text and screenshots

To create a simple mapping application, which provides support for the processes of (1) concept sorting and (2) the editing of a concept sort into the form of a concept map.

With a focus on simplicity, BrainBox does not seek to compete with the ability of commercial charting tools, in terms of providing sophisticated PRODUCTION TOOLS, but rather concentrates on the provision of PROCESS TOOLS, which facilitate the generation and sorting of ideas.

Suggestions about how future implementations might be improved and integrated with other programs

For instance: OLE automation of applications, such as Visio; output as WMF for pasting into word processed documents; support for an A2/A3 virtual work space for large grid inputs; and, a spell checker.

# Chapter Two

## Literature review

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## 2.1 Introduction

This chapter reviews the literature relating to concept mapping. To complete this review, the information from the literature has been divided into four main sections:

- Section 2.1 presents an overview of the chapter contents. In addition, the section presents an overview of the different **map designs** used by mappers. The aim of the overview of map designs is to lay a foundation awareness of the many designs available in preparation for later discussion in which the central position that concept maps take within this thesis is explained more fully.
- Section 2.2 describes the different motivations (i.e. **mapping goals**) which people have in mind when they produce a map. The aim of the description is to find out what mappers wish to achieve and what tools they need (i.e. **mapping needs**) in order to facilitate these achievements.
- Section 2.3 presents a **detailed description** of the different **map designs**. A description of a **design** of a map is a description of a **product**. The aim of the section is therefore to use a description of map designs to assess the utility of the product, resulting from a cross-section of mapping techniques. As a result of the discussion, the selection of the concept map - an informal map design - as the design of choice can be more clearly understood.
- Section 2.4 presents a detailed description of the different **mapping media** used to support the mapping **processes**. The aim of the section is to assess the utility of different processes and thus the utility of the media which support these processes. As a result of the discussion, the selection of concept sorting as the process of choice is more clearly explained.

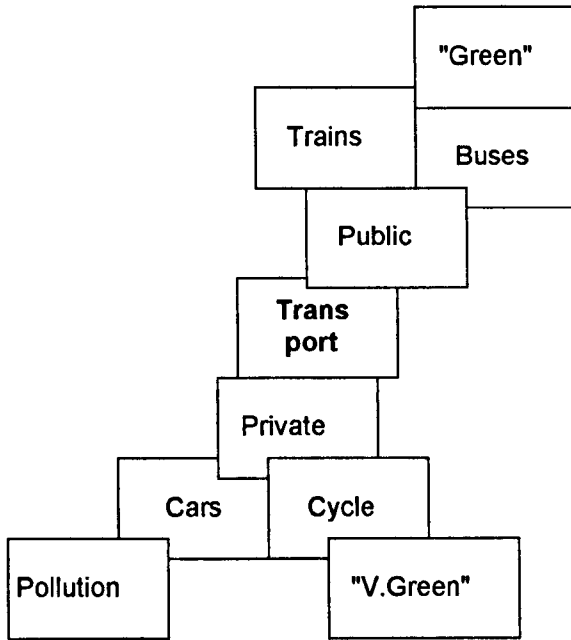
The literature review resulted in six main findings. Firstly, the utility of a computer-based mapping application depends upon the ease with which ideas can be generated and sorted, and not just on the application's ability to produce quality output. Secondly, the map design which provides the best trade-off between ease of construction and the

construction of a model explicit enough to meet most mapping needs, is the informal design called a concept map. Thirdly, the most efficient way in which to construct a concept map is to generate and sort ideas within a dynamic medium - which is to say, the most efficient way in which to construct a concept map is to use a concept sorting protocol to generate and cluster ideas and to then edit the concept sort into the form of a concept map. Fourthly, a computer system which enables a user to concept sort in a dynamic environment, and then to convert the results of that concept sorting exercise into a concept map for future reference, should have a high utility for mappers working alone (or in small groups). Fifthly, the current state of computer display technology is such that concept sorting is best done using move & stick media in large group contexts. Sixthly, there is a distinction between maps as **product** and mapping as a **process**. It may be that a mapping application which makes it relatively easy to create a well-presented map as a product, is not an application which makes it relatively easy to generate and sort ideas as a process.

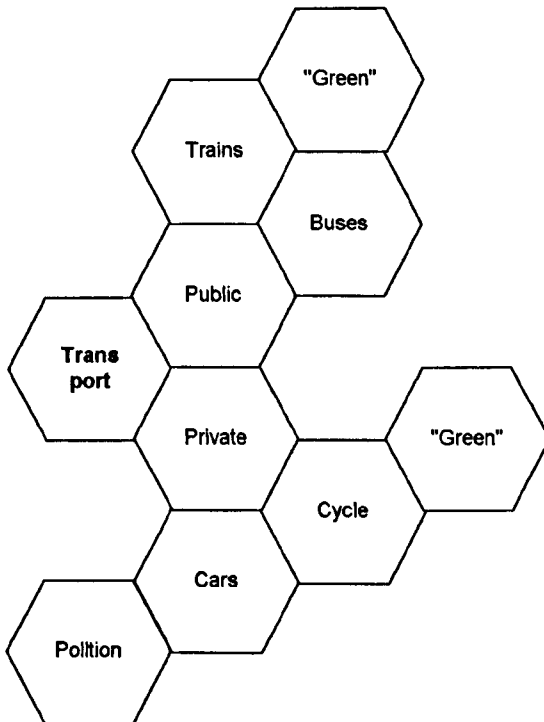
These conclusions indicate that a good place in which to begin to assess the utility of computer-based mapping applications, is to find or create an application which is able to support concept sorting and editing of a completed concept sort into the form of a concept map.

**Fig 2.1: Spatial map designs**

*(The maps presented below are examples of the kind of visual representations referred to in section 2.3.1 as spatial designs. Ideas are written on different shapes and then moved around a work area, until ideas have been clustered into meaningful groups).*



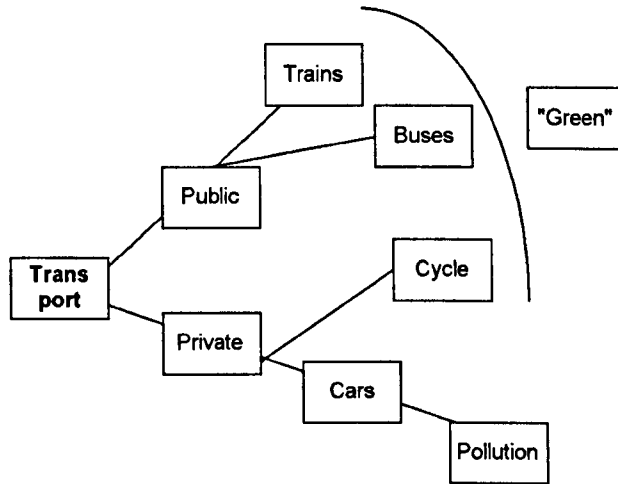
**Concept  
sorting**



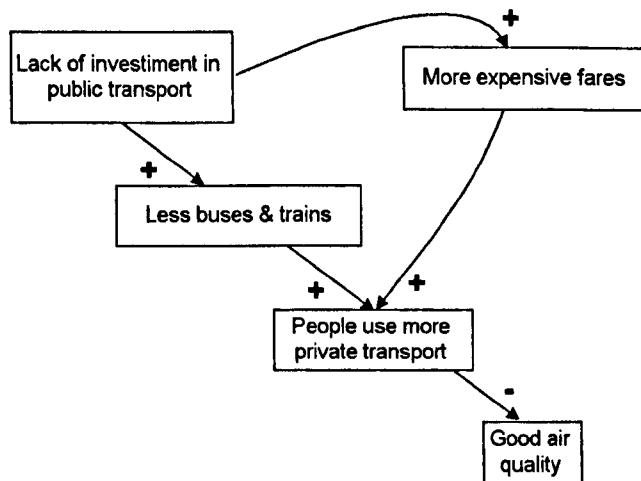
**Thinking  
With  
Hexagons**

**Fig 2.2: Informal map designs**

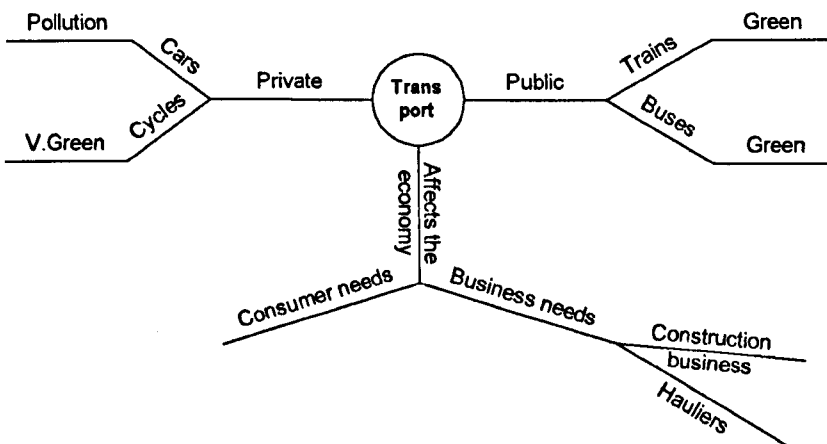
(The maps presented below are *examples* of the kind of visual representations referred to in section 2.3.2 as informal map designs. Notice how simple lines or arrows are used to more explicitly express relationships between ideas).



**Concept map**



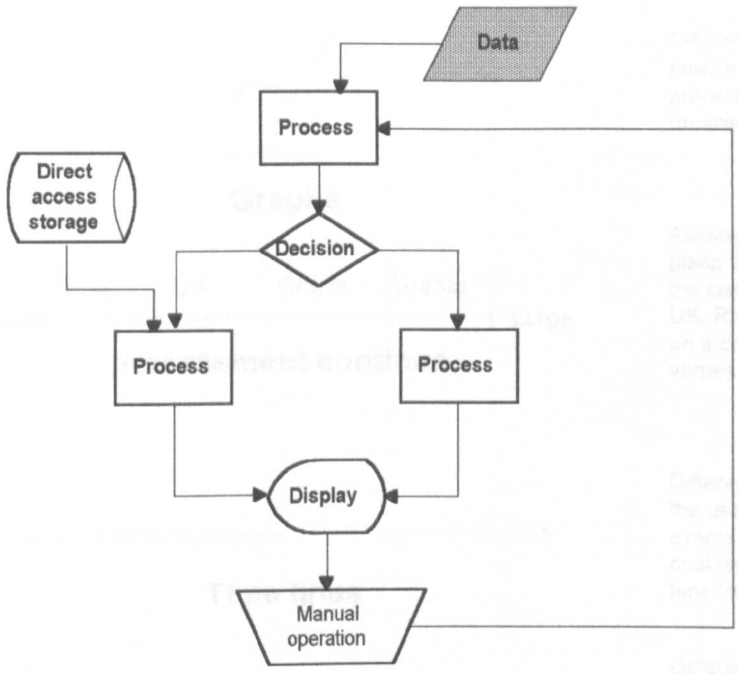
**Causal map**



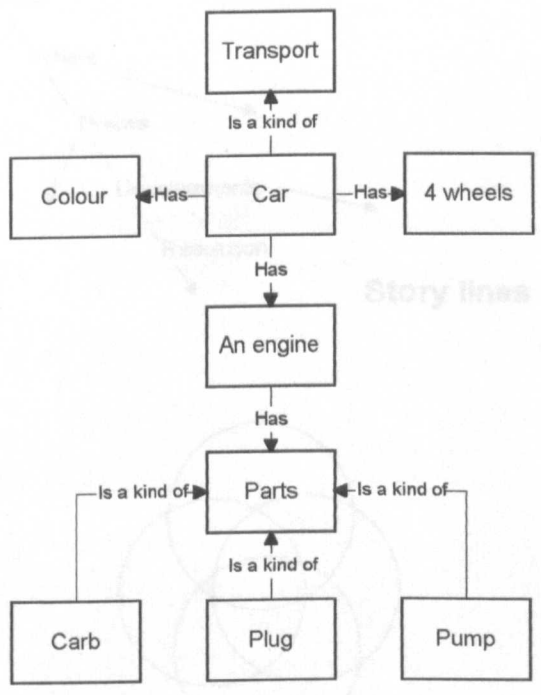
**Buzan map**

**Fig 2.3: Formal map designs**

(The maps presented below are *examples* of the kind of visual representations referred to in section 2.3.3 as formal map designs. The links between ideas use a well-defined syntax. The exact form of that syntax depends upon the kind of formal design being employed).



**Flow chart**



**Semantic net**

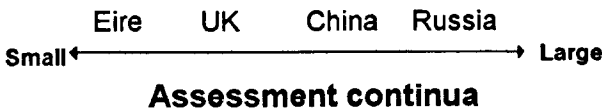
**Fig 2.4: Five template designs**

(The maps presented below are *examples* of the kind of visual representations referred to in section 2.3.4 as template map designs. The links between ideas use a well-defined syntax. A designer creates a visual template into which the user inserts information).



**Graphs**

Different kinds of graphs enable information to be presented in more meaningful ways.

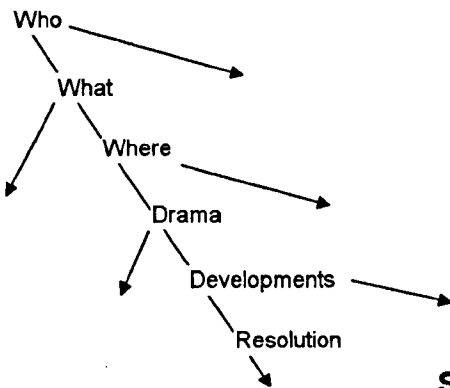


Assessment continua enable users to place things in relation to the subject of the continuum. For instance: Eire, the UK, Russia and China could be placed on a continuum of large countries verses small countries.

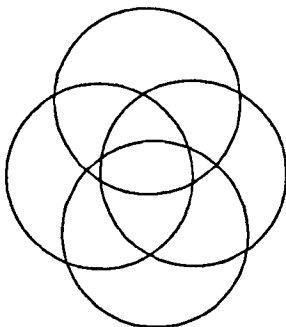


**Time lines**

Different kinds of time lines focus the user on the ways in which events are related in time. In business, a well known kind of time line is the Garntt Chart.



Different kinds of story lines can be used to help an author to structure a story, before writing the detailed narrative. This can be especially helpful, when the author is learning how to write better stories, reports etc. Story lines have been found to be a useful way in which to teach school children how to write better English.



**Venn diagrams**

Venn diagrams can be used to help users classify things.



**Fig 2.5: Three more template designs**

(The maps presented below are examples of the kind of visual representations referred to in section 2.3.4 as template map designs. The links between ideas use a well defined syntax. A designer creates a visual template into which the user inserts information )

**Race**

	Run 1	Run 2	Run 3
Athlete Pete			
John			

Tables are familiar templates, into which information can be placed.

**Tables**

Time	.....
Space	.....
Matter	.....

The relational glossary is a kind of table, in which ideas are defined *in relation* to other ideas.

**Relational glossary**

leads to    leads to    leads to

--	--	--	--

because    because    because

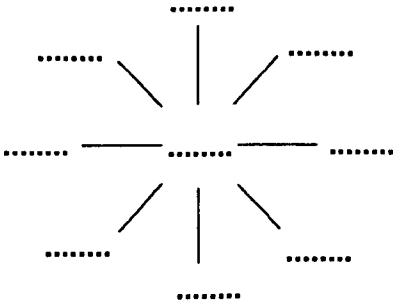
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Causal chains trace the causes and / or the effects of a set of circumstances.

**Causal chain**

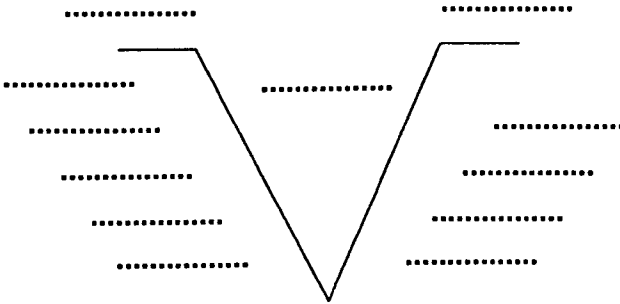
### Fig 2.6: Three further template designs

(The maps presented below are *examples* of the kind of visual representations referred to in section 2.3.4 as template map designs. The links between ideas use a well defined syntax. A designer creates a visual template into which the user inserts information)



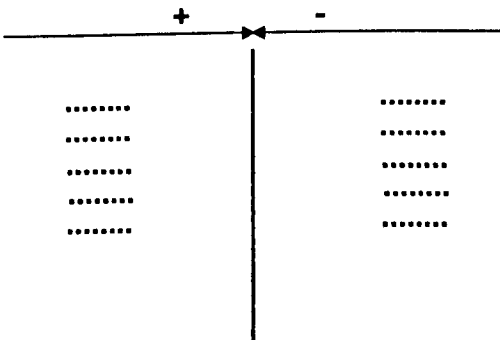
A Webb diagram is a template which helps people to focus on ideas associated with a central concept

**Webb diagram**



A Vee diagram is a template which helps the user to analyse the validity of a belief, or scientific finding. (Users need to be taught what kind of information belongs on each part of the V).

**Vee diagrams**



A force field diagram helps users to focus on the positive and negative forces acting within a domain. When making a decision, the force field diagram can be used so that the decision maker identifies those aspects of the problem domain which s/he can utilise, and those aspects which need to be addressed, if a viable course of action is to be found.

**Force field diagram**

## 2.2 Mapping goals

The main aim of this section is to identify why people construct maps (i.e. generate, sort and connect ideas pictorially), and to identify how to help people to map more easily and effectively. By identifying how maps can be drawn more easily and effectively, it should be possible to decide how various computer applications might contribute to the mapping process.

To find out why people draw maps; a literature search was conducted using the ERIC and PsychLit databases. From this search, nine mapping goals were identified. These mapping goals were:

- **Warm-up goals:** Russell (1979) and Novak (1987) describe using the *process* of mapping to motivate students by getting them to consider what they hope to gain from their course of study.
- **Knowledge goals:** Arunden (1984), Ault (1985), Christen (1988), Novak (1990), Pereiche (1990) and Ruddell (1989) report using the *process* of mapping to help learners to integrate information from a number of sources into a coherent whole.
- **Recall goals:** Rose (1991) and Buzan (1989), who suggest that the *process* of mapping can aid recall and that appropriately designed maps (i.e. the *product* of the mapping process) can be used as quick revision notes.
- **Feedback goals:** Novak and Gowin (1984), Alvarez and Risko (in Novak 1984), Wallace and Minzes (1990) and Lawless (1992) report using maps (i.e. the *product* of the mapping process) to provide teachers with feedback regarding the progress of their students.
- **Problem goals:** Eden (1979) and Checkland (1990) describe the *process* of mapping as a way in which to enhance problem solving in small groups.
- **Solution goals:** Simms (1979) and Simms and Jones (1985) report the use of the *process* of mapping as a way in which to utilise creative thinking techniques and produce better solutions, when problem solving.

- **Preparation goals:** Hodgeson (1992) and Ennals (Personal Communication) suggest the *process* of mapping as an effective way to prepare talks and presentations.
- **Overview goals:** Smee (1990) used maps (i.e. the *product* of mapping) to provide a graphical handout to accompany a talk.
- **Descriptive goals:** Ringland and Duce (1988) describe using maps (i.e. the *product* of mapping) to provide a precise description of a subject domain.

In the following text, the goals outlined above are discussed under the broad headings:

- understanding / memory,
- decision making,
- explanation.

These headings reflect the different interests of:

- those who use maps/mapping in education,
- those who use maps/mapping in business, and
- those who use maps/mapping as a medium of communication.

## 2.2.1 Memory and understanding

The terms memory and understanding are being used here in their common-sense forms. Memory is used in the sense of being able to encode new material into long term memory, and being able to recall that same material at a later date. Understanding is used in the sense of being able to relate new ideas to existing ideas and the ability to use information to solve problems and make decisions. With these definitions in mind, there are four mapping goals related to memory and understanding. In this thesis these are termed: **warm-up goals, knowledge goals, recall goals, feedback goals.**

### **2.2.1.1 Warm-up goals**

Warm-up goals relate to a desire to prepare a student for study. According to Russell (1979), there are two kinds of warm-up goals. The first goal is to encourage an active approach to study by focusing the learner onto the salient features of a new subject domain. The second goal is to motivate the learner by getting them to consider how their achievements on the course could affect their future.

With respect to focusing a student, many educational theorists stress that new knowledge is constructed through an interaction between existing knowledge and the information which a teacher presents to a student (Ausubel in Novak 1987). Therefore, when beginning a new course of study, it is useful for people to map what they already understand about that subject. Such mapping helps people to make their existing knowledge more explicit. The only rider (to the usefulness of a warm-up map) is that mappers who spend too long drawing detailed warm-up maps may create too set a mental model, and not find it easy to update that model in the light of fresh evidence (Stenswold / Wilson 1990).

With respect to motivating the student: at the beginning of a course of study a teacher might get their students to map what they (the students) would like to achieve from the course on which they are about to embark. From this map, the students can then begin to identify what they want to achieve as a result of the course. They can consider how these achievements will affect their future, and thus become motivated to participate more fully in the learning process.

### **2.2.1.2 Knowledge goals**

The use of maps and mapping to attain knowledge goals is the best represented use of maps and mapping within the educational literature (e.g. Arauden 1984, Ault 1985,

Christen 1988, Novak 1990, Pereiche 1990, and Ruddell 1989). Knowledge goals relate to the desire to help learners integrate information from a number of different sources and weld that information into a meaningful whole.

The process of mapping facilitates the welding process. How the process of mapping facilitates the integration of information from multiple sources depends upon whether the map is being constructed in a solo or a collaborative context. In a solo context, mapping focuses the mapper on the salient features of the subject domain. The mapper is asked to pick and choose from the information available, that which is most relevant to the subject of the study. The mapper is then encouraged to chart the associations which exist within this list of ideas. The map helps the mapper to externalise their thinking in a form of internal conversation. By contrast, in a collaborative context, the mapping process acts as a focus for peer group interaction.

Peer group interaction is encouraged by many educationalists (e.g. Piaget in Solso 1991 / Vygotsky in Wertche 1985 & 1991 / Mercer 1987). These theorists believe that knowledge is a socially constructed phenomenon, and that discussion is an effective way to clarify ideas in a learner's head. However, the process of stimulating peer interaction is one fraught with difficulties. According to Slavin (in Topping 1992) and according to Edwards and Mercer (1985), unstructured peer interaction often fails because learners do not know how to interact effectively. The discussion group grinds to a silent halt. The problems associated with peer interaction have led some (e.g. Slavin in Topping 1992) to suggest that the peer interaction needs to be structured if it is to be effective, and others (e.g. Diekhoff 1982) to suggest that a simple mapping protocol may be a way in which such structuring can be achieved.

Two examples of the use of the process of mapping to attain knowledge goals are provided by Pereiche and Novak. Pereiche (1990) reports a number of mapping strategies which teachers used with 11th graders in a Mississippi school district in 1986/87. Pupils

within the district were having problems with writing and comprehension. In the state literacy exam some 53% of the examinees had been unable to write an essay on a theme, even though 85% had been able to answer questions relating to structuring an essay. Pereiche and his team used simple templates (referred to elsewhere in this thesis as crosswords and jigsaws) into which pupils write their ideas. The templates made the process of mapping easy to learn and to administer. Ease of administration meant that teachers soon became interested in the techniques and used the techniques extensively - and successfully. After a two year period, the pass rate for reading comprehension (in the state literacy exam) had risen to 99.2 %, while the pass rate for writing essays had risen to 100%.

Novak (1990) has encouraged the use of the semantic net as an educational tool. In a study using mapping techniques based on Novak's work, it was found that students who chose to use semantic nets tended to do better than those who did not. In the field of science teaching (Arunden 1984), in one spring term 64% of mappers were receiving A or B grades, as opposed to 28.9% of non-mappers, whilst at the other end of the spectrum, 37.8% of non-mappers received grades D to F as compared to 7.1% of their mapping counterparts. However, although several studies show that students who choose to map do better than students who choose not to map, other studies suggest a more pessimistic state of affairs. Novak (1990) cites work which indicates that many students do not use his method of mapping because of the difficulty in drawing semantic nets.

Despite the positive aspects of mapping, there are many who are resistant to it. Feedback provided in interviews (conducted by Novak and his colleagues in America) indicate that many students perceive that the construction of semantic nets is an effective way to understand new subject matter - however, they *also perceive* that the process of constructing semantic nets is effort intensive and has little payback in terms of academic grades. Consequently, many students decide not to use mapping - because they feel that it is too much hassle. Novak (1990) asserts that in America, the dominant educational

culture is one which rewards rote learning. He suggests that learners are not asked to demonstrate an understanding of what they are learning until their second or third year at university - and that as a consequence, unless (and until) the reward system changes relatively few students are likely to willingly use mapping as an aid to learning.

### **2.2.1.3 Recall goals**

Recall goals relate to the desire to improve memory. There are two ways in which maps and mapping can be used to achieve recall goals. First, the process of mapping helps to encode information deeper into long term memory and helps to encode information in the form of a pictorial image. Secondly, pictorial images can be scanned quickly, and thus maps comprising key words and images can be used as an aide memoir - and an effective part of a revision schedule.

Key words (and icons) stimulate the recall of information and help the reader to encode information deeper into long term memory. It is suggested that through increasing the use of the right brain hemisphere the learner can begin to access memories held in the form of images (visual and kinaesthetic), rather than relying on verbalisation and internal self talk alone. Ralph Harber (see Rose 1991) of the University of Rochester showed a number of subjects 2,500 photographs over a seven hour period. The subjects were then shown pairs of photographs, in which one photo was one they had seen, while the other was a photograph which they had not seen before. Subjects were able to recognise between 85% and 95% of the pictures correctly. The results of the Harber study, and others like it, strongly suggest that the mind has powerful image processing and recognition abilities, and that the incorporation of visual stimuli into the memorisation process is an effective way to turn a list of facts into a pattern which is easier to remember.

Two examples of recall mapping are provided by Tony Buzan and Colin Rose. Tony Buzan has done much to popularise the use of recall maps in business and education. His



system of speed reading linked with mapping suggests that the reader identify key words and then arrange them around a central concept. Buzan (1989) suggests the use of colour and icons to further stimulate the ability of people to process and remember pictorial representations. Colin Rose writes about a technique called Accelerated Learning, which is used by several large companies and endorsed by organisations such as UNESCO and a number of US Government Agencies (Rose 1985). One of the tools used in Accelerated Learning is a cartoon based mnemonic, which is used to summarise chapters in a book. Unlike the map design used by Tony Buzan, Rose places his cartoons in a linear order, rather than drawing them in the form of a spray diagram. As the diagram is summarising the contents of a linear text, this format might not be inappropriate, but it does make it difficult for the reader to make connections between ideas introduced early in a text and ideas introduced nearer the end of that text.

#### **2.2.1.4 Feedback goals**

Many theories suggest that learning cannot take place where there is an absence of feedback (e.g. Information Processing Theory in Sage 1981). However, traditional educational measures of understanding have recently been found to be lacking in accuracy, making feedback difficult to obtain. For instance, Trigwell (1990) suggests that examinations often contain problems which, given sufficient rehearsal, become little more than exercises. Trigwell asserts that exams do not measure a learners' ability to apply understanding in a novel situation, but often measure the learner's ability to complete a particular form of exam question. He therefore suggests that alternative forms of feedback should be sought. Among those seeking for alternative forms of feedback are a number of educational researchers who are interested in the use of maps (e.g. Novak / Gowin 1984, Wallace/Minzes 1990, Wandersee 1987, and Lawless 1992). The advantages of maps are that they stimulate an associative way of thinking and encourage a learner to externalise what they know; that the maps act as a reference point for discussion between teacher and

and learner; and that an inability to structure a map soon notifies the teacher when the learner is unclear about how concepts relate to one another.

The following text presents some of the findings of those using maps to collect feedback from students. Novak and Gowin (1984) write that many students are able to answer standard exam questions without being able to understand the first principles upon which the answer depends. In response to this, the two colleagues suggest the use of Vee diagrams and semantic nets.

According to Alvarez/Risko (in Novak 1987) the development of the Vee diagram is based on the assumption that knowledge is not absolute but is dependent on the concepts, theories, and methodologies by which we view the world. Gowin developed the Vee diagram to invite learners to consider the structure of what they believe to be true. The diagram prompts people to consider, given the statement *X leads to Y*: What is the cultural context? What are the observations? and What is the methodology by which such a statement can be derived? In studies, Alvarez and Risko (in Novak 1987) found that using a Vee diagram as part of a biology practical seemed to increase the students' interest and understanding of the experiment and that teachers found the Vee diagrams a useful source of immediate feedback. Such feedback allowed teachers to identify both class and individual misconceptions, so that they could begin to take remedial action. When evaluating the Vee diagrams, teachers found that 57% of the students' findings related to what they expected to be true, rather than to the experimental data. In these cases experimental data was at variance with the final results. Having discovered this dichotomy; the teachers were then able to go back to the class and discuss the point. Using semantic nets, Fraser and Edwards (in Novak 1987) found that mapping was as effective as interviewing when there is a need to gauge whether someone has understood an idea. They also found that both maps and interview strategies seem more effective than written responses. When writing an essay, less able students often wrote ambiguous statements which were marked correct by the teacher - yet which were later found to be

incorrect. As well as providing feedback about how well a student has understood a lesson, maps can also be used to provide feedback about the quality of a course of study (see Wallace/Minzes 1990). An example of this process is provided by Lawless (1992), who investigated the effectiveness of the physics component of a history of science course. Lawless asked both students and tutors to map the course content and he then compared a composite of the student maps with a map prepared by the course designers. He found that the two maps were very different, for whereas the tutors' maps were centred around the concept of radiation and its relationship to waves and particles, the students consigned radiation to the periphery and failed to make any links with waves or particles. (Lawless 1992).

## 2.2.2 Decision making

Goals related to decision support can be split into two kinds, those that are concerned with clarifying the problem, and those which are concerned with clarifying the solution. In this thesis these are termed **problem goals** and **solution goals** (respectively). Problem goals refer to the desire to explore the nature of a problem. The mapper uses the process of mapping to explore the associations between the parts of the problem which they have identified, in the hope that they can gain an insight into the deeper structure of the problem. Such insight helps the decision maker to get to the root of a problem, instead of being caught up in responding to a set of symptoms. Solution goals refer to the desire to collate ideas into a unified course of action. The mapper uses the process of mapping to relate ideas generated during a brainstorming session to the problem in hand. Generating ideas is one thing, being able to apply them is quite another: solution mapping helps facilitate this application process.

### **2.2.2.1 Problem goals**

Psychologists such as Gilhooly (see Gilhooly 1988) suggest that people are better able to address problems when they are able to structure those problems. They also assert that the main difference between an expert and a novice lies in the expert's ability to discern a deeper structure within the information available. Two key workers in the area of using maps to achieve problem goals are Colin Eden (e.g. Eden 1979) and Peter Checkland (e.g. Checkland 1990). What is interesting about both these researchers is that their mapping techniques begin to break down the idea that objective problems exist, and help decision makers to ask themselves how their own (or other peoples) world views affect how problems are perceived and reacted to. The aim of Eden's mapping technique is to help the mapper to chart the chains of cause and effect which may arise from a decision. Such a map helps represent the complex interplay of issues which often surrounds even the simplest of problems. Ultimately, the map should help the mapper to avoid short-sighted decision making by giving the mapper a better overview of the context in which the immediate problem is framed. Eden provides an example of a causal map drawn in consultation with a local government official, regarding his understanding of the finance and staffing environment in which he operated.

Checkland's work is based in Soft System Methodology (which he himself helped to create). Since its development the system has been used in several real world contexts, contributing to the decision making of a number of large organisations, for instance Shell Oil. Shell Oil is involved in a number of diverse business interests; therefore to deal with sophisticated competition, Shell has a group of 500 experts called Manufacturing Function (M.F.) who advise on future strategy. The outcome of a strategy may only be apparent 5 - 10 years from initial implementation, making assessment of MF's efficiency difficult. In the light of this, the head of MF organised a series of meetings with the expressed intention of instituting some form of quality control. The meetings were organised on a workshop basis and had small groups drawing maps and feeding back into the conference as a whole.

### **2.2.2.2 Solution goals**

Simms (1979) suggests that it is easier to generate ideas than it is to apply them. With colleague David Jones, she writes:

"We shall argue that the never-ending hunger for new creativity techniques is partly because the existing techniques do not work very satisfactorily. The problem is not that these techniques do not succeed in increasing the number and divergence of ideas brought to bear on an issue. It is that this success then poses new problems of how to manage and make practical use of the body of creative ideas. For example, how can problem solvers weed out those ideas which are not going to be helpful, without prematurely rejecting those which may be useful with a little modification? How can they relate the different ideas to one another? How can they make explicit, and examine further, the intuitive judgements and experience which led to the ideas, and which may lead to further ideas? How can a team effectively and rewardingly share, negotiate and build upon the complex bodies of personal wisdom and experience in the team?"  
(Journal Of Management Development 1985:4:1:47)

The two researchers claim that (in their experience) the process of mapping ideas augments the use of creative-thinking techniques and is well received by the business community with whom they work. A case study which illustrates this work now follows. Jones and Simms (1985) present a number of maps drawn by the managers of a construction company which wanted to diversify into tourism. Initially ideas were brainstormed onto a force field diagram, making it easier to see the specific forces working against diversification, and helping to discern the kinds of interventions which might be used to surmount those negative forces. Then a few central ideas were made the centre of Webb diagrams. Finally, a causal map was drawn of the kinds of decisions which the management group could take, and how those decisions might interact with one another.

## 2.2.3 Explanation

Previous discussion has touched on the use of maps and mapping as a way to facilitate learning and support decision making. The focus here is upon the use of maps and mapping as a way to augment the explanation of ideas - whether the target audience is physically present (as in a seminar or business presentation), or whether the target audience is physically distant (as when a student reads a text book).

The explanation process will be split into three distinct components. Those components are:

- knowing one's audience,
- conveying an overview so that the audience grasps the key ideas being expounded,
- conveying an exact description of a domain.

The kinds of goals described are: **preparation goals**, **overview goals** and **descriptive goals** - where preparation goals relate to the desire to tailor a message to a recipient, overview goals relate to the desire to communicate an *overview* of a set of key ideas and the structure which holds those ideas together, and descriptive goals relate to the desire to *accurately* communicate a set of key ideas and the structure which holds those ideas together.

### 2.2.3.1 Preparation goals

All professional communicators (such as advertisers, politicians, and teachers) need to model their audiences. They need to build upon what the audience knows by using language with which the audience will feel comfortable. The process of mapping can help a communicator to generate and sort ideas into a form which is suitable for the audience they are to address. Two examples are provided by Tony Hodgeson and Richard Ennals. Tony Hodgeson (1992) suggests that, when a facilitator works to improve the quality of a

management meeting, it is useful for the facilitator to map individual managers' associations with the subject of the meeting, prior to the meeting taking place. Such mapping helps people who have to address the meeting to gain an insight into the mood of the group, and to draw attention to any areas of agreement or disagreement which might affect the outcome of the meeting. Political commentators, such as Prof. Richard Ennals (of the Business Faculty at Kingston University - personal communication), will as a matter of course make a mental map of the audience to which they are speaking. They do this so that they can adopt a language and a style which lends most impact to their message. Such speakers need to be aware of the associations which different audiences hold for different words, or else they leave themselves (and their ideas) open to misunderstanding.

### **2.2.3.2 Overview goals**

Overview goals can be achieved through the construction of a map, which is then distributed to the audience. Providing the map is simple to follow, it can help the audience to better follow the communicator's arguments (Lambiotte, 1989). The value of the map is that the detail of the unfolding discussion is always seen in its proper context. The reader (or listener) does not have to strain working memory by trying to perceive the structure of the discussion, or by having to keep in mind several strands of a complex argument.

### **2.2.3.3 Descriptive goals**

Descriptive goals represent the desire for a precise description of the domain of discourse. Semantic nets and flow charts are common map designs by which people achieve descriptive goals. People who use descriptive mapping include knowledge engineers and people concerned with the mapping of hard knowledge domains. One problem with using a map to achieve a descriptive goal is that knowledge has to be expressed in terms of a limited syntax. This inevitably means that (depending upon the form of representation

used) some ideas are expressed well and other ideas are expressed less well. Schank's semantic grammar (see Aitkinhead / Slack 1985) is a good example of a descriptive map, which although it is claimed to capture any utterance (using a limited set of primitives), does not make for easy reading.

## 2.2.4 Mapping goals - a summary

From the preceding description of the nine mapping goals, it may be seen that seven of the nine goals are process-based and concerned mostly with the integration of ideas in the mapper's mind. That is, the *process* of mapping provides the mapper with 'mental scaffolding' which helps the mapper to generate and/or sort ideas and the relationships between those ideas. The *product* of mapping is used mainly as an aide-memoir, and need not be sophisticated in form. The next section indicates how concept maps as *product*, and concept sorting as the first part in the *process* by which concept maps are constructed, meet the needs of the majority of mapping goals.



## 2.3 Map designs

A convenient way in which to assess the utility of the product of a given mapping process is by discussing the appearance of the map. One way in which to discuss the appearance is to discuss the map design - that is, the particular conventions which rule the interpretation of the map.

The overall aim of this section is to make clear why this thesis focuses on the production of concept maps. The text explains how the design of a concept map provides the best trade-off between *the effort required to generate, sort and present ideas* and *the ability of the resulting presentation to model the domain of discourse well enough to achieve most mapping goals*.

A search through the literature referred to in the previous chapter and a further search through business and computing journals disclosed the following list of map designs (examples of which are provided in **Section 2.1**):

- Concept sorts (McGraw & Harbison Briggs 1989)
- Thinking With Hexagons (Idon Software 1990)
- Soft System Methodology (Checkland 1990)
- Assessment continua (Clarke 1991)
- Causal chains (Clarke 1991)
- Relational glossaries (Zimmer 1984)
- Crosswords (Pereiche 1990)
- Force field diagrams (Clarke 1991)
- Story lines (1991)
- Tables & graphs (Clarke 1991)
- Time lines (Clarke 1991)
- Vee-diagrams (Novak 1990)
- Venn diagrams (Clarke 1991 / McGraw & Harbison Briggs 1989 / Wandersee in Novak 1987)
- Webb diagrams (Clarke 1991)
- Concept maps (Clarke 1991)
- Causal maps (Asher 1976 / Axelrod 1976 / Blalock 1971 / Eden 1978)
- Buzan mind maps (Buzan 1989)
- Semantic nets (Abelson 1986 / Barr & Feigenbaum 1980 / Charniak & McDermott 1985 / Leiber 1991 / Novak 1990 / Ringland & Duce 1988, Zimmer 1984)
- Flow diagrams (Clarke 1991 / Idon Software 1990 / McGraw & Harbison Briggs 1989 )

Map designs do not all have an equal utility. Each design has its own particular strengths and weaknesses; thus the utility of a map design can only be assessed in relation to the degree to which the design's strengths facilitate a given mapping goal and the extent to

which the design's weaknesses inhibit attaining a given mapping goal. In geography it has been long recognised that an appropriate map design should emphasise important information, whilst downplaying or even omitting unimportant information. To quote a phrase: the map is not the terrain (Downs / Stea 1975).

From the previous section, it is evident that five mapping goals are attained primarily as a result of the mapping process. These five mapping goals are: warm-up goals, knowledge goals, problem goals, solution goals and preparation goals. *The final product of the five goals listed* can be a map of simple design, because the map is only to be used as an aide-memoir. *Of the remaining four goals: recall goals* are attained through a mapping process which leads to the production of a map, the design of which is easy to scan quickly; *feedback goals* are most easily attained through the use of a map design which it is easy for the student to draw; and *overview maps* are most easily attained through the use of a map design which it is easy for the reader to read. Only descriptive goals require a complex design, in order to fully capture the detail of an accurate description.

In summary:

- Five out of the nine mapping goals require a map design which does not conflict with the need to generate and sort ideas quickly and easily, but which can, if required, enable the mapper to recall the process at a later date.
- Three out of the nine mapping goals require only a simple map design.
- One out of the nine mapping goals requires a complex design.

Discussion will now turn to assessing map designs in the light of the summary presented above. In particular, discussion will seek to determine which map design (or designs) would best meet the mapping needs outlined in the summary.

Nineteen map designs are listed at the start of this section. To simplify the discussion, these designs are classified into four groups:

- **Spatial designs**, which use spatial positioning to communicate relationship
- **Informal designs**, which use simple links to communicate relationships
- **Formal designs**, which use complex links to communicate relationships
- **Template designs**, which use templates or a formalised mapping technique to achieve specific mapping goals and to support the work of inexperienced mappers.

In the discussion which follows, each of these categories is explained in more depth and its strengths and weaknesses explored.

### 2.3.1 Spatial designs

Spatial designs use the spatial relationships between ideas to highlight associations. Ideas are arranged into natural clusters. Examples of such clustering can be seen when looking at concept sorts and the results of Thinking With Hexagons sessions (Thinking With Hexagons being a commercial form of concept sorting).

A map utilising a spatial design represents an externalisation of a domain of discourse, explicit enough to *indicate* the mapper's mental model, yet not explicit enough to make that model fully clear.

Spatial designs are most often used as a form of pictorial shorthand - a graphical aide-memoir. Spatial designs are not well suited to use as a way in which to record a mental model for future reference, either by the mapper or by others. The lack of explicit relationships can make the map confusing and ambiguous to read.

The great strength of a spatial design is that when used as an aide-memoir a map can be constructed relatively quickly. From the list of mapping needs, it is evident that maps

utilising a spatial design can be an effective way in which to facilitate mapping goals such as warm-up goals, knowledge goals, problem goals, solution goals, and preparation goals. It is also evident that, if constructed in a dynamic medium, a spatial design can be used as the foundation for more complex designs - the spatial map being edited into the form of an informal or a formal map as required.

### **2.3.2 Informal designs**

Informal designs represent relationships between ideas through clustering and through the use of simple links. The three most common forms of informal design are: concept map, causal map, and Buzan mind map.

The simplest kind of informal map is the concept map (See Clarke 1991). The concept map uses lines (or arrows) to represent relationships. The addition of lines and arrows represents an increase in the effort required of the mapper. However, in practice, the addition of lines and arrows makes a map much easier to read.

A concept map is therefore an ideal design to use to attain all mapping goals, except for those which are descriptive. The only draw-back to the utility of a concept map over the utility of a concept sort, is that the addition of lines and arrows to the map requires the mapper to expend more effort. On reflection, this need not be a problem. Since the construction of a concept map only requires the addition of lines and arrows, then it is evident that should the concept map be constructed in a dynamic medium, the mapper can create a concept sort in order to clarify their thinking, and then convert the concept sort into a concept map once they have a model of the domain clear in their mind. By using a dynamic medium and not adding lines or arrows until the model is clear, the mapper reduces the effort required to construct their map to an absolute minimum.

A map design which is slightly more descriptive and complex than that used in a concept map is the causal map design (e.g. Asher 1976, Axelrod 1976, Blalock 1971 and Eden 1978). A causal map adds 'causal' symbols (such as + and -) to the links between ideas, and represents concepts as bipolar opposites. For instance, the idea *'light'* becomes *'light as opposed to dark'*. This way of expressing an idea communicates that a positive causal link will result in 'light' whilst a negative causal link will result in 'dark'. The price of adding information about causality is that the design of a causal map takes longer to implement than that of a concept map. Causal maps can be quite complex. The complexity of the map allows a sophisticated representation of many domains related to decision making. Thus, causal maps tend to be used by historians, managers, political scientists and social scientists. For people who do not need this level of detail and accuracy, the extra time taken to encode causal information is wasted time. Therefore causal maps are mainly of use in problem mapping and overview mapping, and have a limited application elsewhere.

So far, concept maps and causal maps have been reviewed. Both these designs use nodes and links to represent ideas and associations. An alternative is to use a link-only approach, such as the one popularised by Tony Buzan. Buzan feels that nodes make an informal map unnecessarily difficult to scan. He therefore suggests a map design in which ideas are written along the length of links. Writing ideas in this way certainly creates a map which looks more streamlined and aesthetically pleasing, however in practice the utility of the map may not be as great as a first glance might suggest. Two main difficulties become apparent when using a Buzan style map. Firstly, words are written at angles to the page making it difficult to read some of the ideas. Secondly, there is only a short space in which to write ideas, and so ideas have to be expressed as key words (rather than as sentences or paragraphs). For Buzan, this may not be a problem because Buzan suggests that identifying key words is a good way in which to record information for easy revision. However, hunting for an expressive key word can be difficult; therefore Buzan is increasingly moving towards the belief that cartoons are the best way in which to

stimulate recall (Buzan 1989). The use of such cartoons has the effect of by-passing both the problem of words being written at angles and the problem of being limited to key words. It does however raise the additional problem of the time it may take to think of and to draw cartoons. With time a consideration, the most effective use for a Buzan Map may be recall mapping. The creative effort used to produce a Buzan map can help to encode information in the mapper's mind, as well as providing a revision aid which can be scanned quickly.

Of the informal designs reviewed, the concept map provides the best general purpose utility. Other designs provide more utility for specific mapping goals, but do not enable a mapper to address the same range of mapping goals.

### **2.3.3 Formal designs**

Formal designs use a syntax which is precise in the way in which it describes the domain of discourse. This makes the design of a formal design ideal for descriptive mapping. Mappers use formal designs, such as flow diagrams and semantic nets, to accurately model the interrelationship between 'atomic' elements within a domain. The main advantage of a formal design is that such a design enables the mapper to accurately capture the ideas and relationships which exist within the domain being mapped. The main disadvantage related to the use of formal designs is the time and difficulty associated with reducing the domain which is being mapped to a set of atomic primitives.

Over the years many researchers (see: Abelson (1986), Barr and Feigenbaum (1980), Charniak and McDermott (1985), Leiber (1991), Novak (1990), Ringland/Duce (1988)) have devised a number of different designs in an attempt to more accurately and easily capture different aspects of human knowledge. Two of the most common forms of formal designs are flow diagrams and semantic nets.

Semantic nets are currently being used by Novak and his colleagues in both America and Australia (see above). However, the use of mapping techniques based on the semantic net has met with a mixed reaction. The time taken to think at an atomic level seems to demotivate many would-be mappers. A far better reaction to mapping has been found by Pereiche (also reported above) who has introduced several template-based designs into schools in the Mississippi region of the American South. The contrast between the reactions of students to the two different forms of map design, suggests that although the drawing of semantic nets has been found to have a positive educational effect, template designs have more utility because of the way in which they focus on the holistic aspects of the domain being mapped and because they take less time to complete.

With regard to flow diagrams, there are a number of contexts in which accurately modelling the flow of information is indispensable, for instance in the design of a computer system or a machine. However, in other contexts the difficulties involved in accurately modelling a flow of information can make a flow diagram misleading - which is why Checkland (1981) evolved the template design called soft system methodology (see Checkland 1981 & 1990). In practical terms, flow diagrams are best used in situations where a domain is amenable to precise modelling; in other situations, a mapper should consider using an informal design or some form of template map.

### **2.3.4 Template designs**

A number of mapping techniques require the mapper to sort ideas using a number of pre-drawn templates. Templates help inexperienced mappers by prompting the mapper. Rather like a crossword in a newspaper, the blank spaces on a template prompt the mapper to focus on specific aspects of the subject domain. For instance: a story line map helps an author to check that they have thought through all the key elements needed for a story. It acts like a checklist. Clarke (1991) reviews a number of templates - though there may well be many others. Examples are: assessment continua, causal chains, positives and



negatives, story lines, tables and graphs, time lines, Venn diagrams, Vee diagrams, and Webb diagrams.

Templates can be used to facilitate any mapping goal. Being pre-designed structures, templates are less flexible than other forms of mapping, but this loss in flexibility is often made up for by the ways in which the template helps the mapper towards achieving a specific goal.

One of the most powerful forms of template map is Soft System Methodology. Soft System Methodology guides decision makers through the process of modelling other people's perspectives. Decision makers often find that problems and solutions are more 'subjective' than 'objective' in nature, which means that traditional management techniques such as flow diagrams are unable to express the situation in an appropriate way. Such diagrams often ignore the human component in a problem. By contrast, soft system methodology recognises that many decisions are 'political' in nature, and provides a rigorous technique to navigate the decision maker through the process of modelling opinions which may be ill defined and which may involve a number of competing perspectives. The technique has been found to be effective in a number of private and public sector organisations. Organisations as diverse as Shell Oil, the NHS and the DSS (see Checkland 1981 and 1990).

### **2.3.5 Map designs - a summary**

From the previous discussion, different kinds of map design can be seen to have the following strengths:

- Maps based upon a spatial design are well suited as an aide-memoir, a short term note of ideas and relationships.
- Maps based upon a spatial design, if implemented within a dynamic medium, can be used as the foundation for more complex designs. Working in this way, the mapper

uses the conventions of a spatial design to generate and sort ideas with a minimum of effort. The mapper then converts the final map into the form of the more complex design. For example, the mapper can construct a concept sort which clarifies their mental model of a subject, and then add appropriate lines and arrows to convert the concept sort into a concept map.

- Informal map designs include concept maps, which are an effective general purpose tool with which to achieve eight of the nine mapping goals listed previously. The maps are easy to construct, particularly if constructed in the two-stage process outlined above. The maps are also expressive of the model in the mapper's mind.
- Formal map designs (such as flow diagrams, semantic nets) are appropriate where the mapper needs to represent ideas and relationships precisely.
- Templates are a good way to support the use of maps by people who are inexperienced in mapping, and can be used to support people who have a particular mapping goal for which a template has been devised.

The different designs also have the following weaknesses:

- Maps based upon a spatial design can only represent an overview of the domain being mapped, and therefore much of the information is held at an implicit level. In consequence, spatial maps may not adequately support a mapper who has to map a large subject domain, and may not be adequate for a mapper who needs to draw a map for others to read at a later date.
- Maps based upon informal designs require the mapper to explicitly represent both ideas and relationships. This means that informal maps take longer to draw than spatial maps.
- Maps based upon formal designs take the most time to construct because the mapper has to fully think through the relationships which exist between the various elements within the subject domain. Such a representation may be difficult in instances in which either the subject domain is not amenable to precise description, or the mapper does not have sufficient knowledge to make such a description possible.

- Templates, while helping mappers to represent certain specific ideas, tend not to be good general-purpose map designs.

The conclusion of a description of map designs must be that concept maps provide the best general-purpose map design with which to achieve most mapping goals. In addition, it should be noted that the most efficient way in which to construct a concept map is to construct a concept sort in a dynamic medium, and to edit that concept sort into the form of a concept map once a model of the domain is clear in the mapper's mind.

## 2.4 Mapping media

In this section, the strengths and weaknesses of computer-based mapping are compared and contrasted with the strengths and weaknesses of other mapping media. The criterion upon which the assessment is made is the question: *To what extent does the medium being assessed facilitate the construction of a concept sort and enable the editing of that concept sort into the form required by more complex designs?*

Mapping media include any media in which it is possible to draw a picture. However, some media are better suited to the mapping process than others. Based on the literature reviewed in section 2.2 and on a number of interviews with mappers, it was possible to distinguish four kinds of mapping media. The four kinds of mapping media (see **fig 2.7**) are: write-once media, write & wipe media, move & stick media and computer-based media.

A write-once medium is a medium in which it is difficult (if not impossible) to erase a map or part of a map, once it has been drawn. An example of a write-once medium would be paper. The main problem with a write-once medium is that the mapper has to draw their map correctly first time - it is therefore very difficult to generate and sort ideas a few at a time. If any changes need to be made to the map, the map has to be rewritten. If the map is not rewritten then it becomes progressively more untidy, as more and more corrections are made. Write-once media do not provide the mapper with a dynamic work environment.

One possible way to reduce the effort involved in rewriting a complete map is to use write & wipe media, such as whiteboards and blackboards. Write & wipe media allow the mapper to erase part of the map, without requiring them to re-draw the whole of the map. An ability to edit a map does allow for some limited concept sorting. However, the need

to erase even part of the map and re-write it still requires a fair degree of effort and can be frustrating if the mapper is attempting to sort a large number of ideas.

More dynamic than the write-once media and write & wipe media are move & stick media. Whilst being almost as cheap and as easy to learn as the static techniques described in the preceding section, move & stick techniques provide the mapper with a dynamic work space in which to externalise their exploration of the subject being mapped. Ideas are represented on separate pieces of card or plastic and can be moved around the work area. The need to erase and re-draw or re-write ideas is kept to an absolute minimum. Move & stick techniques are the traditional protocols used by mappers engaged in concept sorting - and providing the sorting takes place on a suitable surface, it takes very little effort to stick the results of the concept sort to the work surface and add the lines and arrows necessary to convert the concept sort into a concept map.

Computer-based media provide a new alternative to move & stick protocols. A computer provides an electronic environment in which it is possible to generate and sort ideas with relative ease. Comparing computer-based media with move & stick media; it is apparent that the quality of the product is significantly increased: for example it is easy to print out from a computer; and the ease of the process is marginally increased: for example, there is no need to stick ideas down on the work surface to stop them 'blowing away'. However, there are two potential problems which for some will offset the potential gains brought by using a computer. Firstly, screen size can be constricting to those without access to large-screen technology. Secondly, when working in groups, people like to feel that they can control the development of the map - thus, some groups may not like to use a computer with a single mouse input.

**Fig 2.7: The advantages and disadvantages of different mapping media**

Medium	Example(s)	Advantages	Disadvantages
<b>Write-once</b>	Pencil and paper	<p>Pencil and paper are a cheap way in which to draw a map.</p> <p>Pencil and paper are probably the cheapest way in which to draw a coloured map.</p> <p>It is easy to quickly brain dump ideas onto a sheet of paper.</p>	<p>It is very difficult to make changes to the map, which means that maps have to be completely re-drawn, if they need revision.</p> <p>Write-once media do not provide much support for collaborative mapping, and are mainly useful for solo work.</p> <p>People without artistic skill can find it difficult to draw a map in a write-once environment</p>
<b>Write &amp; wipe</b>	Whiteboard	<p>Write &amp; wipe allows a mapper to draw maps, either alone, or in a group setting.</p> <p>Write &amp; wipe is more dynamic than write-once, because it allows changes to be made to the map.</p>	<p>Whiteboards tend to be attached to walls, which means that the maps cannot be easily distributed to others.</p>
<b>Move &amp; stick</b>	Concept sorting/ Thinking With Hexagons	<p>Move &amp; stick is both cheap and flexible.</p> <p>Move &amp; stick is ideal for supporting both solo and group work.</p> <p>Finished maps can often be photocopied and distributed, or kept for future reference.</p>	<p>Move &amp; stick media require a large work area, if there are a lot of ideas to map.</p>
<b>Computer-based mapping</b>	ABC FlowCharter / C.K.Modeller / COPE / gIBIS / InfoMap / Mind Maps Plus / SemNet	<p>Any number of changes can be made in an electronic environment, helping the mapper to maintain a neat working environment.</p> <p>It is easy to distribute electronic maps to others.</p> <p>Computers allow maps to be linked so that several (related) maps can be worked on at any one time.</p> <p>Computers can provide a virtual work space.</p>	<p>Computer equipment is expensive.</p> <p>If the mapper does not have access to a large screen and/or some form of multiple input, then it may be difficult for a group to map collaboratively.</p> <p>There is a lack of 'hands-on' feel for mappers working in a group.</p>

## 2.5 Summary

Nine mapping goals were identified (Section 2.2): warm-up goals, knowledge goals, recall goals, feedback goals, problem goals, solution goals, preparation goals, overview goals, and descriptive goals. Review of the goals indicated that most are process-based and that of those where product was required, the nature of that product need only be simple.

Four basic products - i.e. map designs - can be identified (Section 2.3): spatial designs, informal designs (including concept maps), formal designs and template designs - of which only the first two are simple. Spatial designs are well suited to use as a visual aide-memoir, but not to the production of a map to be referred to at a later date. The simplest design which might be used as a reference at a later date is a concept map. The conclusion of section 2.3 was therefore that the greatest utility and simplicity would be obtained if a map based upon a spatial design, for example a concept sort, were used to clarify the mapper's mental model of the domain; and that once clarified, the concept sort were edited into the form of a concept map.

Four kinds of mapping media - write-once, write & wipe, move & stick and computer-based - were assessed with their ability to facilitate the construction of a concept sort and their ability to enable a concept sort to be edited into the form of a concept map - or any other map design the mapper might wish (Section 2.4). The conclusion of section 2.4 was that for most mapping needs a computer should make an ideal mapping medium, except for mapping in a group context. In a group context, it might be found that move & stick protocols are more appropriate because of the expense of large screen technology and the difficulty with providing group members' access to the computer input.

## 2.6 Conclusions

Eight points emerged from the literature review:

- Most mapping goals use the visual organisation of ideas as a form of mental scaffolding. Thus the utility of a computer-based mapping application depends upon the ease with which ideas can be generated, sorted and connected - and not just the application's ability to produce quality output.
- The map designs which best facilitate the generation and sorting of ideas are spatial designs, such as concept sorting and Thinking With Hexagons.
- The simplest map design which facilitates the connection of ideas is the informal design called a concept map.
- The best media in which to generate, sort and connect ideas are dynamic media.
- Spatial designs express much of the mapper's mental model only implicitly. They are therefore not wholly useful when a mapper wishes to record the results of a sorting session for future reference. It is therefore helpful if mapping takes place within a dynamic environment, so that the results of the sorting session may be edited into the form of a concept map.
- A computer-based system which enables a user to concept-sort in a dynamic environment, and to convert the results of that concept-sorting exercise into a concept map for future reference, should have a high utility for mappers working solo.
- Because of the current state of computer-display technology, computer-based media are less desirable than move & stick techniques, when engaged in group work.
- There is a distinction between maps 'as product' and mapping 'as a process'. Software which makes it relatively easy to create a well-presented map, is not necessarily software which makes it relatively easy to generate, sort and connect ideas.

These conclusions indicate that in order to understand the utility of computer-based mapping applications, a good place to start is to find or create an application with the facilities necessary to support concept generation and sorting, and the facilities necessary to convert a concept-sort into a concept map.



# Chapter Three

## Existing applications

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## 3.1 Introduction

The conclusion of chapter two was that to understand the utility of computer-based mapping applications, an application had to be found or developed which would enable users to concept sort ideas within a dynamic medium, and then enable users to transform the results of the concept sort into the form of a concept map.

This chapter reviews the five existing computer-based mapping applications which were most closely associated with concept mapping at the start of the study (in 1992). The aims of the chapter are twofold: firstly, to find out whether there is an existing application which might be used to gain feedback from mappers; and secondly, to find out what kinds of facilities commercial mapping applications provided in 1992.

The chapter is split into three sections. In the first section all five computer-based mapping applications are reviewed briefly. In the second section, the most popular commercial computer-based mapping application (ABC FlowCharter) is reviewed in more depth. In the third section, there is a discussion based on the points raised in each of the reviews. The main theme to emerge from the discussion is that most mapping applications provide a range of useful facilities, but that ultimately all the applications reviewed here have serious design flaws with respect to the process of constructing concept maps. In particular, each application requires a number of mouse or key operations to input an idea, and a large proportion of the screen space is taken up by tool bars and menus. Both problems inevitably mean that despite the fact that all the mapping applications are capable of producing well-presented output, the software is continually interfering with the user's flow of thought. *In effect, the applications appear to have been designed with product rather than process in mind, and are therefore only of real use to someone who already knows what their map is to look like, and needs to draw that map with a high level of presentational quality.*

## 3.2 Five reviews

Five applications suitable for concept mapping were reviewed:

- ABC FlowCharter
- C.K.Modeller
- gIBIS
- Mind Maps Plus
- SemNet

The applications were chosen either because they had extensive references made to them in the research literature and / or because they had a reasonably high commercial profile.

Each review is organised into three parts:

- A list of the facilities available in the application (see **fig 3.1**)
- A screen shot, to provide an example of the application's interface design
- A short précis relating to the applications design features.

**Fig 3.1: A glossary of terms used to describe the facilities found in computer-based mapping applications**

<b>Facilities</b>	<b>Explanation</b>
Dynamic ideas	...refers to the facility to move ideas around the map surface, so that the user is able to explore relationships between those ideas.
Dynamic links	...refers to the facility to draw a link between two ideas, and for that link to move if either one of the ideas is repositioned.
Expand function	...refers to a facility which enables a mapper to capture a single idea on one map and make that idea the central idea on a new map.
Export map	...indicates the ability to output a map in bitmap or vectored formats.
Export text	...refers to any facility which enables the mapper to collate ideas from one or more maps, in the form of a list which can be exported to a word processor.
Idea mobility	...refers to the facility to move one or more ideas between maps, so that an idea or a group of ideas is not stuck on any one map.
Maximise work space	... refers to the ability to minimise the screen space taken up by toolbars and menus.
Notes	... refers to whether the mapper can 'hide' notes under an idea.
Notice board access	...refers to the ability of a group of people to use the application as a map-based notice board.
Paragraph text	...refers to the ability of the mapping software to represent ideas which consist of more than a few words.
Virtual work area	...refers to a work area which is larger than the size of the screen.
Zoom function	...refers to whether the mapper can zoom out to gain an overview of their map, when working in a virtual work area.

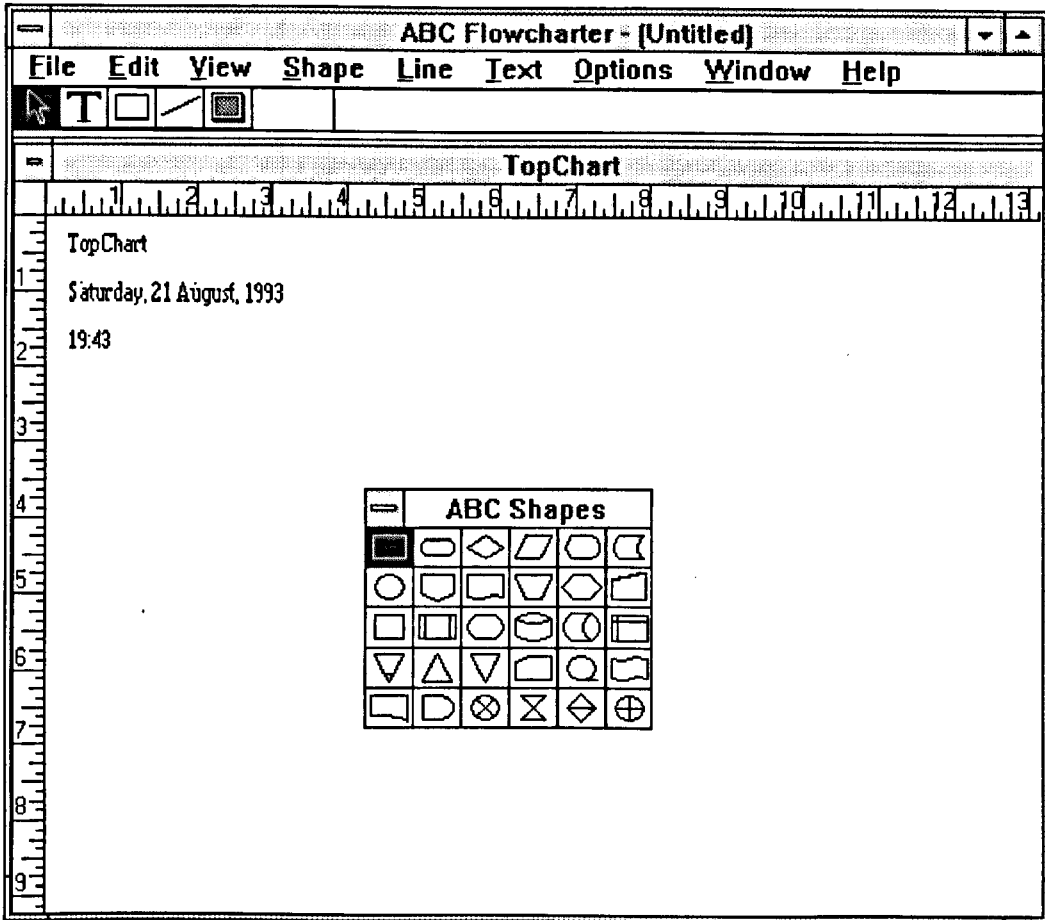
### 3.2.1 ABC FlowCharter

The aim of ABC FlowCharter is to enable users to produce flowcharts and organisational charts for inclusion in reports, projects and presentations. In 1992 ABC FlowCharter was the industry-standard charting application, widely used by Times 100 companies. The following description of ABC FlowCharter comes from the author's use of ABC FlowCharter Version 1.13.

ABC FlowCharter provides mappers with a large virtual work area equal to nine sheets of A4 square. Onto this work area users can place ideas and links. If they wish, users can opt to expand concepts onto fresh maps, with electronic links between maps being created automatically. Ideas boxes may be moved or copied between maps, either individually or in groups. A zoom function enables the user to gain an overview of the map as a whole, or to work on a part of a map. Links are dynamic and can be simple lines or annotated arrows. Output is of high quality and can be copied and pasted into other electronic documents, such as word-processor files (using the Windows meta-file format). With all these features, ABC FlowCharter is certainly a much better mapping tool than any general-purpose paint or draw packages (available in 1992). In particular, text handling is far superior because the user is not required to wait for screen re-draws. However, ABC FlowCharter does not provide for all mapping needs. There are two main constraints which affect the software's utility. Firstly, much of the screen space is taken up with the menu bar and the main toolbar. Secondly, the way ideas are added and edited involves a number of mouse clicks per idea, which can tend to interfere with a mapper's train of thought, and becomes irritating if a number of ideas need to be added at once.

On balance, although ABC FlowCharter is very effective as a tool with respect to the construction of a quality product, it is not an environment in which it is easy to concept sort, and therefore is not an environment suited to the needs of the concept mapper.

Fig 3.2: A screen shot from ABC FlowCharter 1.13



**Fig 3.3: An overview of the facilities in ABC FlowCharter 1.13**

<b>Facilities</b>	<b>Exist</b>
Dynamic ideas	✓
Dynamic links	✓
Expand facility	✓
Export map	✓
Notice board	
Idea mobility	✓
Paragraph text	✓
Notes	✓
Small tools	✓
Virtual work area	✓
Zoom facility	✓

**(NB: A tick indicates that ABC FlowCharter contains the facility to the left of the tick).**

### 3.2.2 C.K.Modeller

C.K.Modeller was developed by Idon Software (in association with Shell Strategic Planning) in the mid 1980's. The original aim was that C.K.Modeller would facilitate Thinking With Hexagons by allowing mappers to input the results of a Thinking With Hexagon session - thus allowing the possibility of laser-printed output. The sources for the following review were: a demonstration of C.K.Modeller; the Thinking With Hexagon Manual; a review of C.K.Modeller (Goodwin 1992); interviews with three business consultants, who use C.K.Modeller as part of their work; and a telephone conversation with one of the managers at Shell UK.

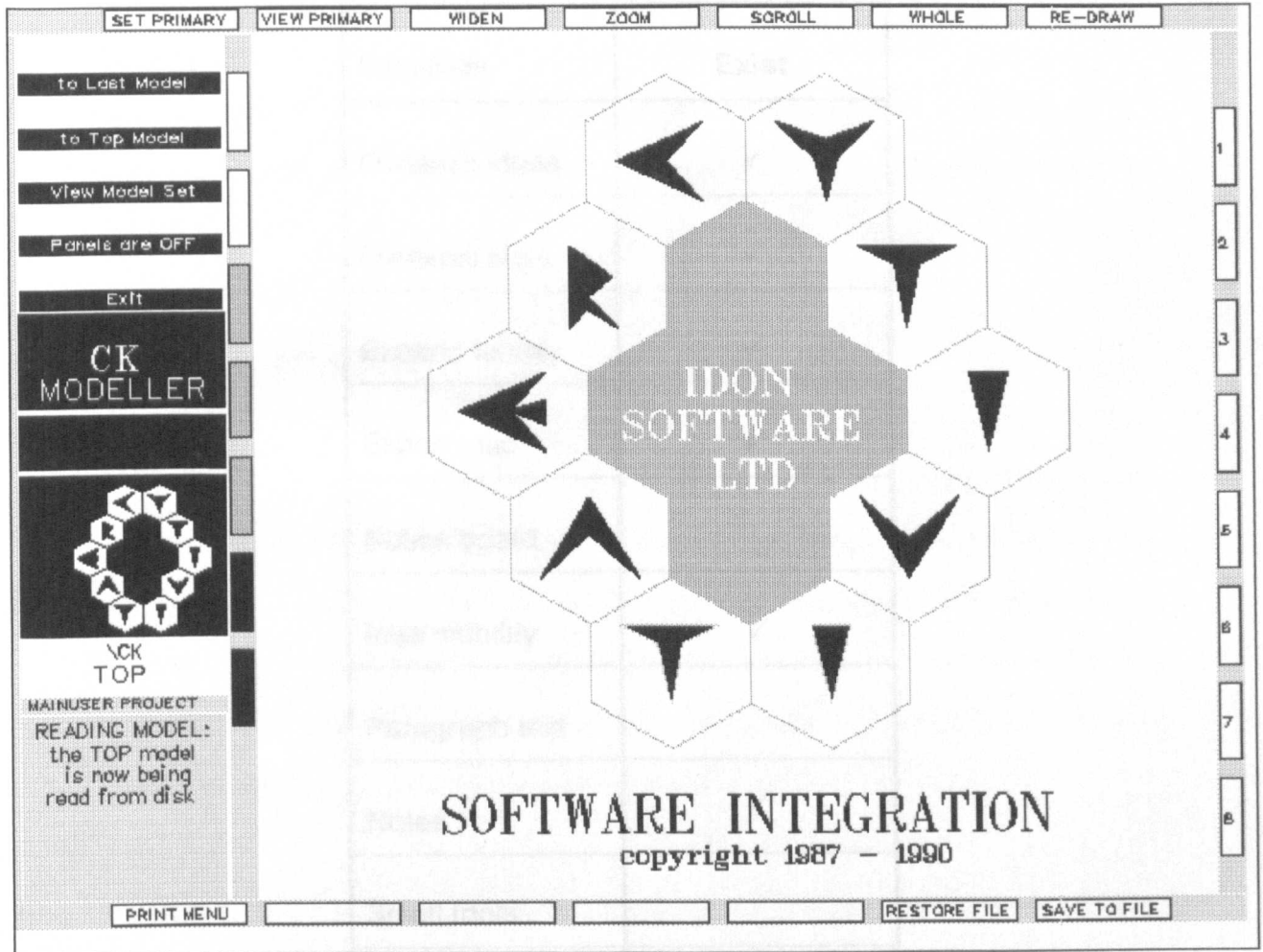
In terms of this thesis, C.K.Modeller is of most interest because it is a computer implementation of a move & stick technique, and as such is one of the few products for which a direct comparison can be made between the utility of a computer-based mapping application and the utility of mapping on a table top. When asked to make such a comparison between C.K.Modeller and Thinking With Hexagons, two of the three business consultants interviewed said that they tended to use mapping in a group context, and therefore preferred to map on a table top and input the results of the mapping session into the computer at a later date. The two consultants said that they felt that the software's main utility was to present the results of a Thinking With Hexagon session with a high standard of presentation allowing the maps to be distributed at the highest levels of management.

To probe the issue further, a call was made to the offices of Shell Strategic Planning. Speaking to one of the managers, the impression was given that although Thinking With Hexagons sets were widely used in the department, C.K.Modeller was rarely used. The implication was that most of the people the respondent knew did not feel happy using the software - and that people prefer the hands on feel that working with a Thinking With Hexagon set allows. Idon software was not prepared to make a copy of C.K.Modeller



available for testing, but from the information available, the main problems with the utility of C.K.Modeller appear to be the result of what the computer press has termed an idiosyncratic interface (Goodwin 1992). In relation to ABC FlowCharter, the C.K.Modeller interface is relatively primitive. There is little that C.K.Modeller can do that ABC FlowCharter cannot do better - and more ergonomically. This is likely to be so until the program is re-implemented and given a Windows-based interface.

Fig 3.4: A screen shot from the C.K.Modeller demo disk



NOTE: A disk indicates that C.K.Modeller contains the facility to the left of the tick!

**Fig 3.5: An overview of the facilities in C.K.Modeller**

<b>Facilities</b>	<b>Exist</b>
Dynamic ideas	✓
Dynamic links	✓
Expand facility	✓
Export map	✓
Notice board	
Idea mobility	✓
Paragraph text	
Notes	✓
Small tools	
Virtual work area	✓
Zoom facility	✓

**(NB: A tick indicates that C.K.Modeller contains the facility to the left of the tick).**

### 3.2.3 gIBIS

gIBIS is a computer implementation of a planning methodology called IBIS, which was developed by Kunz and Rittel in 1970. (The name 'gIBIS' stands for *graphical* IBIS). The IBIS model suggests that decision making involves an unfolding *discussion* between *stakeholders*. Each stake holder will tend to take a *position*. The eventual decision reflects a resolution of conflicting positions. The following discussion is based on two articles: Begeman and Conklin (1988) and Begeman and Conklin (1989).

Users of gIBIS can input issues and arguments onto a kind of electronic bulletin board. Once an argument or a position has been posted, others can attach further positions and arguments - so that the work space contains an unfolding dialogue. According to Conklin and Begeman, people report that once they have learned to use the gIBIS *way of thinking*, they find that it helps them to home in on critical problems; and to detect incompleteness and inconsistency in a plan. Users say that displaying a decision graphically helps them to expose axe grinding, hand waving and clever rhetoric.

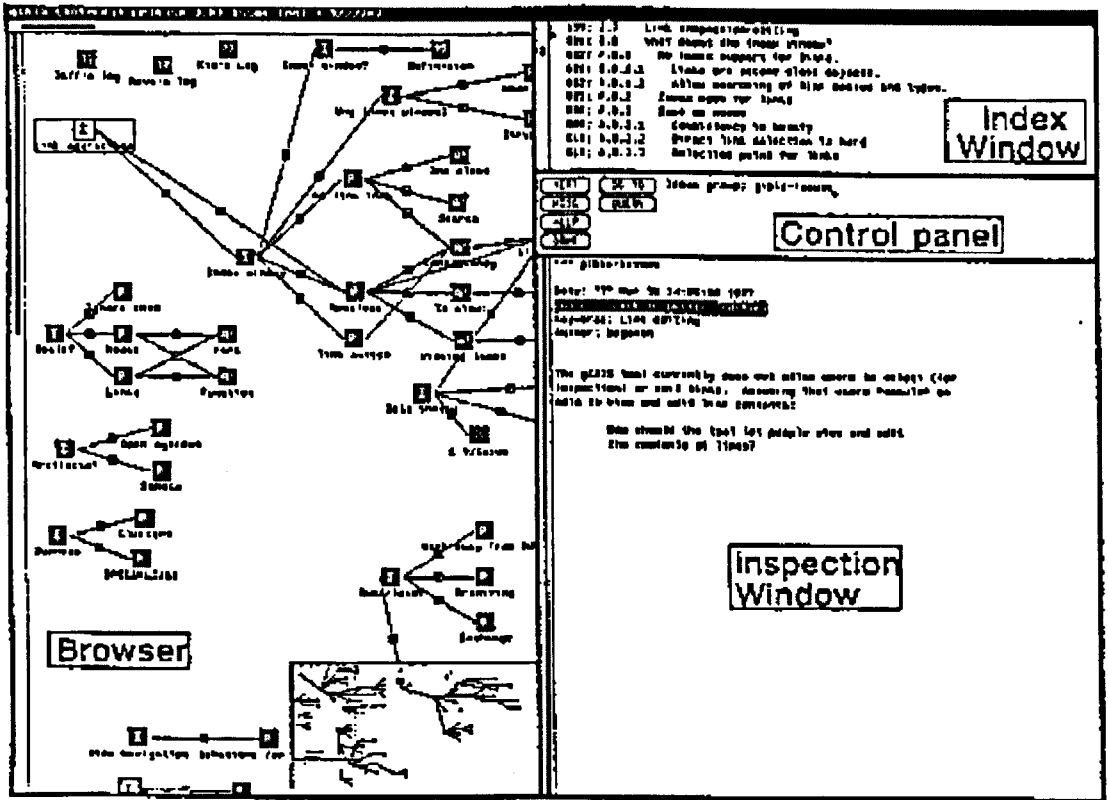
However, there is a problem associated with gIBIS, which if not addressed can undermine the positive aspects of the application. The problem is that gIBIS forces writers to represent ideas using relatively few words. This means that, while gIBIS can represent simple ideas easily, it can be difficult to represent complex ideas in an unambiguous way. Representing a complex idea as a dozen or more simple ideas may not communicate exactly what the writer had in mind at the time of writing.

The overall conclusions of the reviewers of the gIBIS systems seem to be that gIBIS is a useful tool for those who need to explore ill-defined problems, and that gIBIS provides a forum for discussion, which gives a project 'a sense of coherence'. gIBIS enables a work group to build up a map of the group's thinking without the group meeting together at a single geographical place. Whether this is ultimately a good or a bad thing is a subject for

future research, but what can be said is that there are a number of users who perceive that it is a good thing, and who believe that a graphical bulletin board adds a new dimension to their work. gIBIS is an interesting product to review after C.K.Modeller, because the experiences of gIBIS users suggest that, although mapping applications might not be suitable for supporting group work in real time because users like the 'hands-on' feel of physical mapping media such as Thinking With Hexagons, an appropriate mapping application nevertheless might be used to support mapping by groups who are separated by time or distance. In the case of gIBIS, the system provides a place where members of a group can post ideas over a period of time, without the members of the group having to meet together - with the resultant map being used to focus future meetings.

With respect to the process of constructing concept maps, gIBIS is a less effective tool than ABC FlowCharter. The interface adds complexity to the mapping process, rather than making that process easier.

Fig 3.6: A screen shot from GIBIS



NB: This scanned screen shot from Conklin and Begeman (1989) provides an impression of the way in which the GIBIS system represents information.

**Fig 3.7: An overview of the facilities in gIBIS**

<b>Facilities</b>	<b>Exist</b>
Dynamic ideas	✓
Dynamic links	✓
Expand facility	✓
Export map	✓
Notice board	✓
Idea mobility	
Paragraph text	
Notes	✓
Small tools	✓
Virtual work area	✓
Zoom facility	✓

**(NB: A tick indicates that gIBIS contains the facility to the left of the tick).**

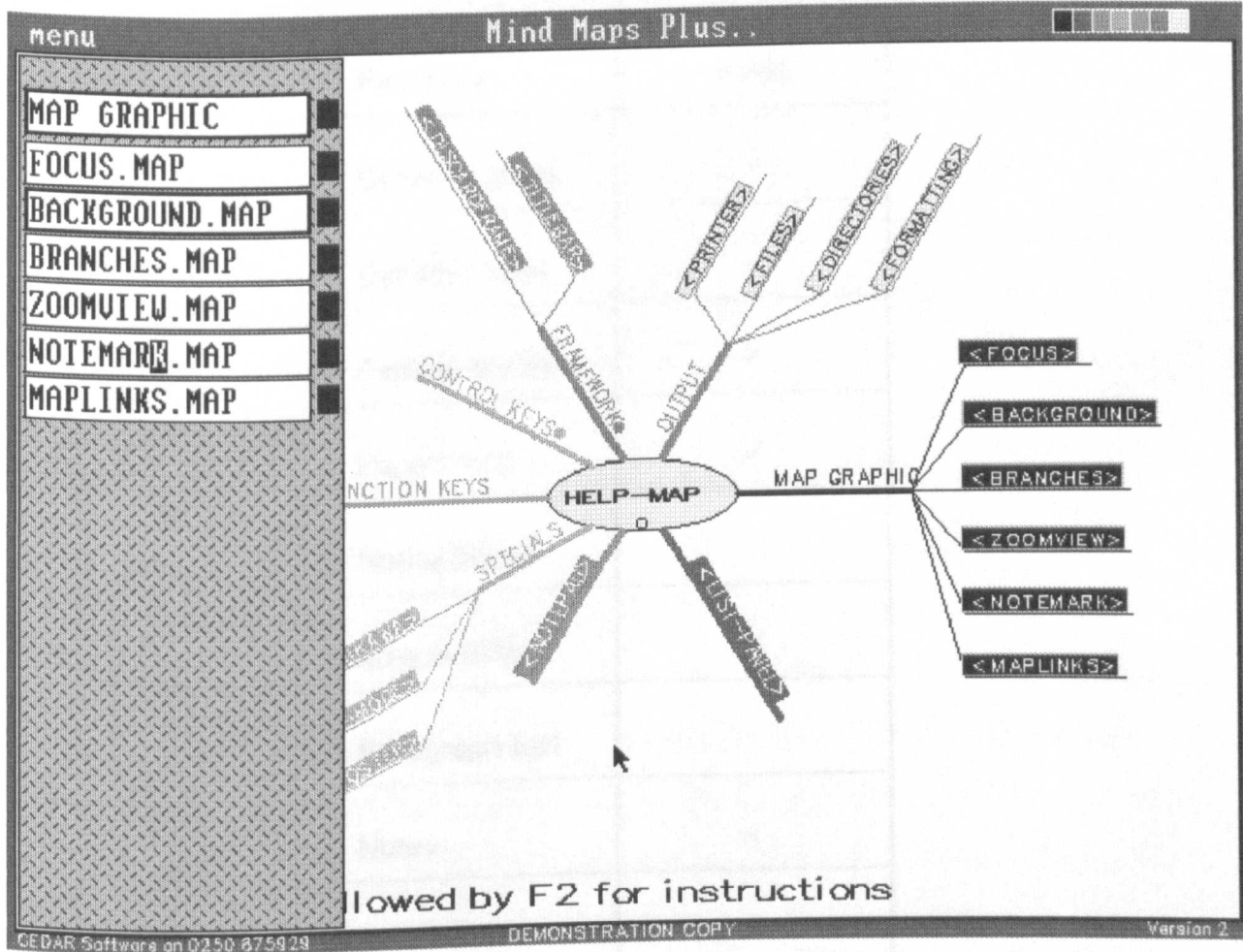
### **3.2.4 Mind Maps Plus**

The following discussion is based on documentation and a working demonstration of Mind Maps Plus supplied by the Buzan Centre.

As with ABC FlowCharter and C.K.Modeller, Mind Maps Plus enables users to add and sort ideas in a dynamic environment. Unfortunately, Mind Maps Plus suffers from the same drawbacks as the two aforementioned programs: Mind Maps Plus requires a number of mouse / key actions to add an idea and covers much of the screen space with tool options. Moreover, unlike ABC FlowCharter and C.K.Modeller, Mind Maps Plus also limits the mapper to working with the mapping techniques devised by Tony Buzan. For those who like the Buzan way of working, the program is a boon. For those who do not like the Buzan way of working, the program is constraining. All ideas are written on lines which branch out from a central concept. This works well when the aim is to use the program to think associatively, so that one idea sparks another, but it can be irritating because new ideas always have to be fitted somewhere on the tree. It is difficult to brainstorm a number of ideas and leave them on one side for a while. Even for those who do like the Buzan-style of map design, Mind Maps Plus suffers from a number of problems. As ideas are added to a map, some of the ideas are written at an angle to the screen, and in a font which is not very clear to read. The conclusion must therefore be that Mind Maps Plus is of use to those who specifically want to draw Buzan-style maps, but does not have the flexibility to facilitate the generation and sorting of ideas, as required by those constructing concept maps.



Fig 3.8: A screen shot from Mind Maps Plus



(NB: A tick indicates that Mind Maps Plus contains the facility to the left of the tick.)

**Fig 3.9: An overview of the facilities in Mind Maps Plus**

<b>Facilities</b>	<b>Exist</b>
Dynamic ideas	✓
Dynamic links	✓
Expand facility	✓
Export map	✓
Notice board	
Idea mobility	✓
Paragraph text	
Notes	✓
Small tools	
Virtual work area	✓
Zoom facility	✓

**(NB: A tick indicates that Mind Maps Plus contains the facility to the left of the tick).**

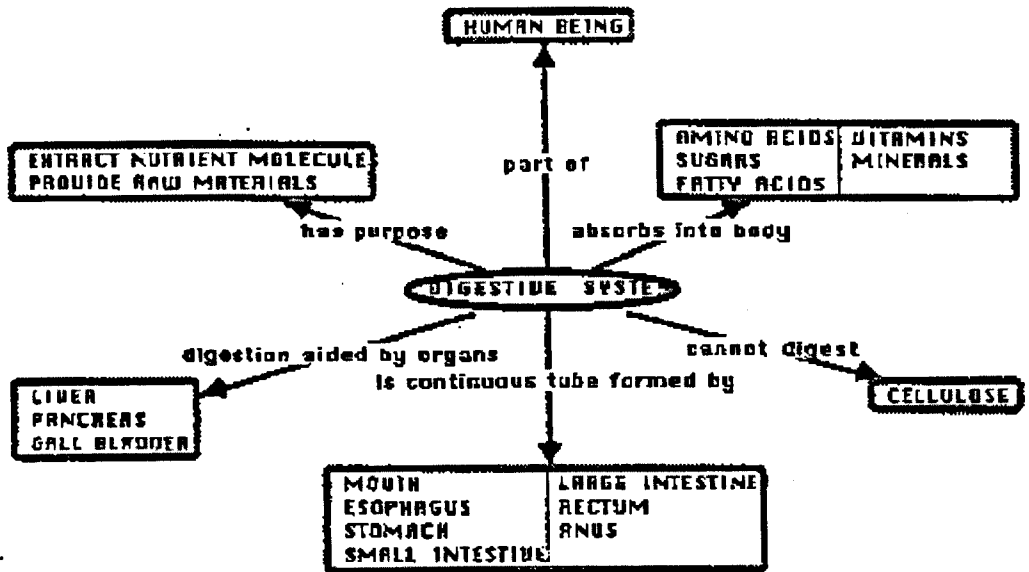
### 3.2.5 SemNet

The following discussion is based on the author's use of SemNet, the SemNet manual, and several articles written by SemNet's author, Kathleen Fischer (e.g. Fischer 1990, Fischer *et al* 1987 & 1990). SemNet is a Macintosh-based application which provides users with a template semantic net. As is true of many templates, the map design is relatively constricting for those who know how to map and want to draw maps with any degree of complexity. Inputting ideas takes several mouse clicks, making SemNet a difficult environment in which to brainstorm. In addition, SemNet can only display ideas which are immediately associated to one another.

In relation to other mapping applications, SemNet has very little in the way of facilities. Ideas cannot be moved around, and there is no way in which to get an overview of the subject domain. Neither is there any way to print out a whole map, or work with multiple inputs. In short, it would seem that SemNet has few of the facilities that mappers might find useful. However, despite the limitations, SemNet has been found to have a positive effect on learning (Fischer 1990). Fischer's results suggest that the use of simple templates can encourage people to use maps, who might otherwise feel that they do not have time to learn to use more complex mapping techniques. In SemNet's case, the utility of a program would appear to be in the way that it prompts users to generate associations and to think through how those new ideas relate to the idea posted in the centre of the screen.

With respect to the construction of concept maps, SemNet is inadequate. The effort involved in the generation and sorting of ideas is much more than that required by someone constructing a concept map using move & stick media on a table top.

Fig 3.10: (Scanned) output from SemNet



**Fig 3.11: An overview of the facilities in SemNet**

<b>Facilities</b>	<b>Exist</b>
Dynamic ideas	
Dynamic links	
Expand facility	✓
Export map	✓
Notice board	
Idea mobility	
Paragraph text	
Notes	✓
Small tools	
Virtual work area	
Zoom facility	

**(NB: A tick indicates that SemNet contains the facility to the left of the tick).**

### 3.2.6 Summary of the facilities found in the five applications reviewed

Fig 3.12: A table summarising the facilities available in each of the applications reviewed previously

Facilities	ABC	C.K.	gIBIS	M.M.+	S.N.
Dynamic ideas	✓	✓	✓	✓	
Dynamic links	✓	✓	✓	✓	
Expand facility	✓	✓	✓	✓	✓
Export map	✓	✓	✓	✓	
Notice board			✓		
Idea mobility	✓	✓		✓	✓
Paragraph text	✓				
Notes	✓	✓	✓	✓	✓
Small tools	✓		✓		
Virtual work area	✓	✓	✓	✓	
Zoom facility	✓	✓	✓	✓	

(NB: A tick indicates where a particular application contains a particular facility)

The five preceding reviews indicate that the best computer-based mapping application, from the viewpoint of someone who wishes to construct concept maps, is ABC FlowCharter. As a consequence, the subsequent section in this chapter will review ABC FlowCharter in more depth.

## 3.3 ABC FlowCharter revisited

The aim of this section is to describe ABC FlowCharter Version 1.13 in more depth than the review of the program presented previously. ABC FlowCharter was chosen for an additional review because, with respect to the construction of concept maps, it is the most sophisticated and user-friendly of the systems previously reviewed.

The description of ABC FlowCharter begins with a description of the opening screen (see **Fig 3.13**). There are a number of features worth noting about this screen. There is a floating shape palette, which the user can use to define the shape tool displayed on the toolbar (under the menu bar). As may be seen, the shape currently selected is a rectangle. Next to the shape tool, there is a text tool and a line tool. The text tool enables text to be placed on the map without being enclosed in a shape. The line tool enables lines or arrows to be drawn between shapes (or text). Customisation of lines, shapes or text is achieved by using the select tool to select the object(s) to be edited and accessing the appropriate menu option (or pressing the appropriate function key), to activate a pop up dialogue. Next to the line tool is a button to activate the shape palette, if the shape palette has been hidden. Moving further right, is a text field. Typing or editing text in this field alters the text displayed in the currently selected object. Around the edge of the visible work space are rulers and scroll bars. However, unless the user is drawing maps on a 17" screen, it is likely that s/he will want to use the option to hide the rulers and maximise the available space (see **Fig 3.14**) - though even with the rulers hidden, 15% of the vertical space is still lost, which on a 640x480 screen is enough to make a map feel cramped. In terms of working in a Windows or Macintosh environment the scroll bars are standard, though navigation is also enabled by the nine square grid, which may be seen nestling between the toolbar and the right hand scroll bar. By clicking the nine square grid, a user can move left, right, up, down, and diagonally. The grid operates the pictorial equivalent to the page up / page down command in a word processor. It is probably more efficient than the scroll bars because it takes up so little space. It is therefore a pity that there is not an option to

hide the scroll bars and navigate using the grid alone. Turning now to the zoom facility, a screen shot showing the zoom facility in action may be seen in Fig 3.15. The zoom-out allows an overview of the current page, and/or all the used pages. In the zoom-out mode, shapes appear as outlines and items of text appear as a grey blobs. It is possible to edit the map while zoomed out, however, doing this requires the mapper to remember what the individual grey blobs of text say. In effect, working this way is only helpful when rearranging a map to improve its presentation, but is not very practicable when sorting ideas. To sort ideas it is best to work zoomed in.

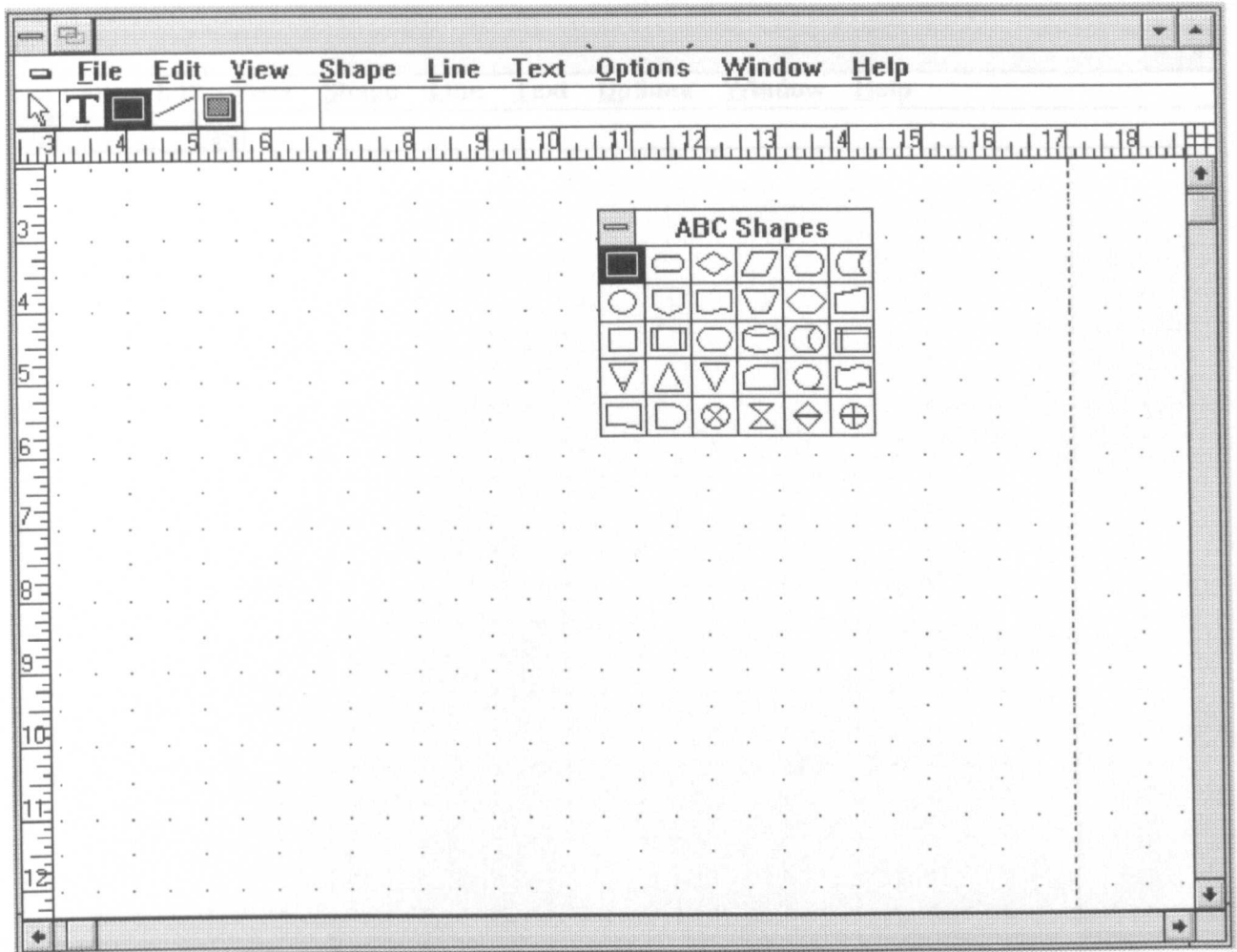
To add ideas, the shape tool has to be selected. Once selected, a new shape is added to the map every time the mouse is clicked. To add text to a shape, the user must click on the edit field. Whatever is typed in the edit field is then automatically echoed in the shape. This has the advantage that there is no need to have separate tools for allowing objects to be moved and for allowing object text to be edited, but has the disadvantage that the mouse has to be moved a relatively long distance before editing can take place. This may not seem like a long operation, but when the user has many ideas in mind and wants to externalise them, the additional mouse clicks soon become an irritation - and become a severe distraction, when there is a need to import a block of text from a word processor and split it into 50 separate objects on the map surface. On consideration, it would have made more sense to allow the in-place editing of text.

Having generated a number of ideas and sorted them spatially, it is relatively easy to add lines or arrows. Firstly, the user must select the line tool. Then, the mouse must be dragged along the map surface, or clicked on two objects. In the second case, the line becomes attached to the two selected objects, so that wherever the object is moved the line moves with it. Attaching lines to ideas sounds like a good idea in theory, but in practice, the line rarely ended up in a position which looked good, and it is more work to re-position the line than if the line and the object had been moved separately in the first place.



To summarise the facilities described above, despite a number of useful tools being provided and despite the obvious ability of ABC FlowCharter to draw maps presentable enough to give to others or to paste into word processed documents, a number of design issues make ABC FlowCharter a difficult environment to use to support the process of generating and sorting ideas. The number of mouse clicks involved in editing ideas and lines soon begins to seriously interfere with the utility of the software, as does the proportion of the screen space taken up by menu bars and tool bars.

Fig 3.13: A screen shot showing the opening screen displayed by ABC FlowCharter



**Fig 3.14: A screen shot showing the opening screen displayed by ABC FlowCharter 1.13, after the rulers have been hidden to maximise the screen space**

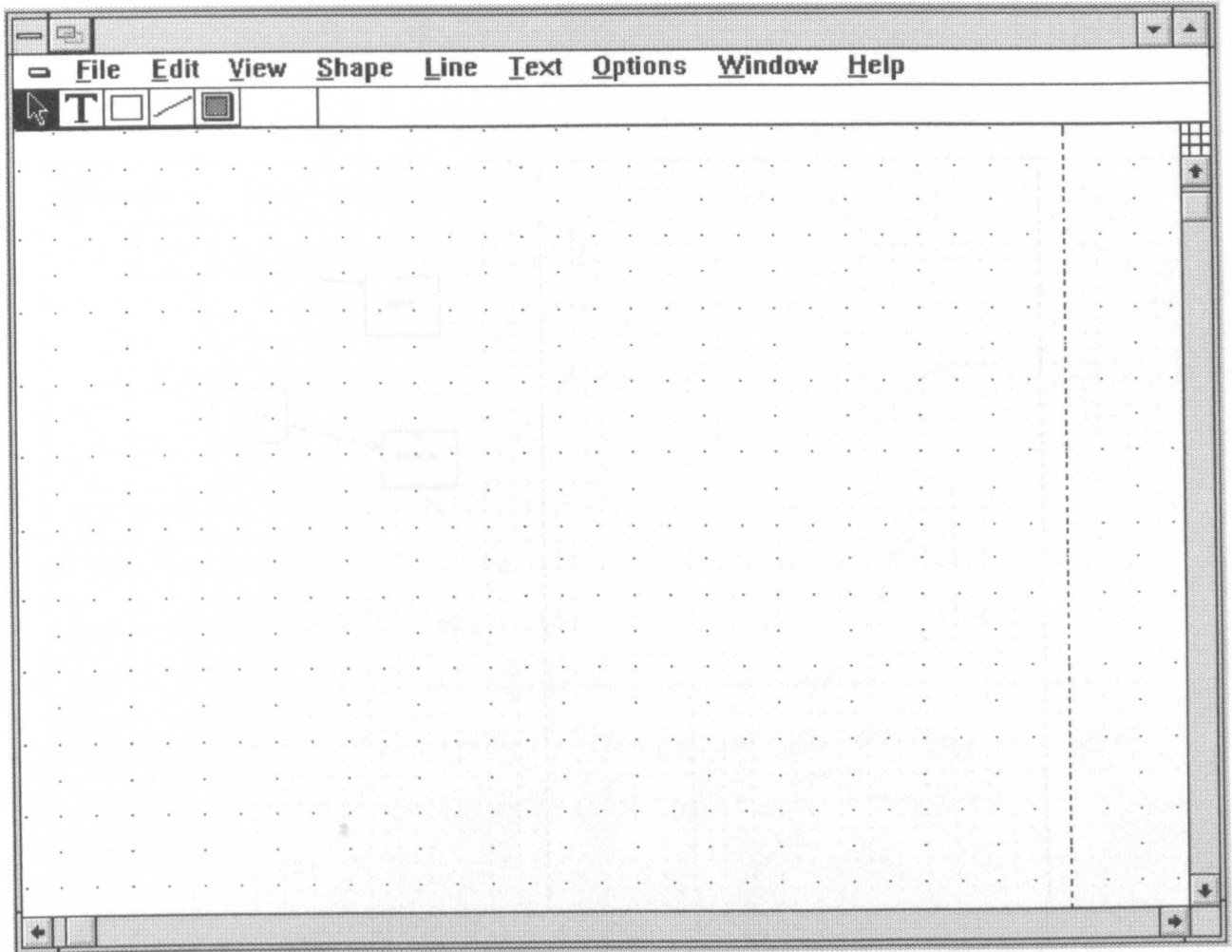
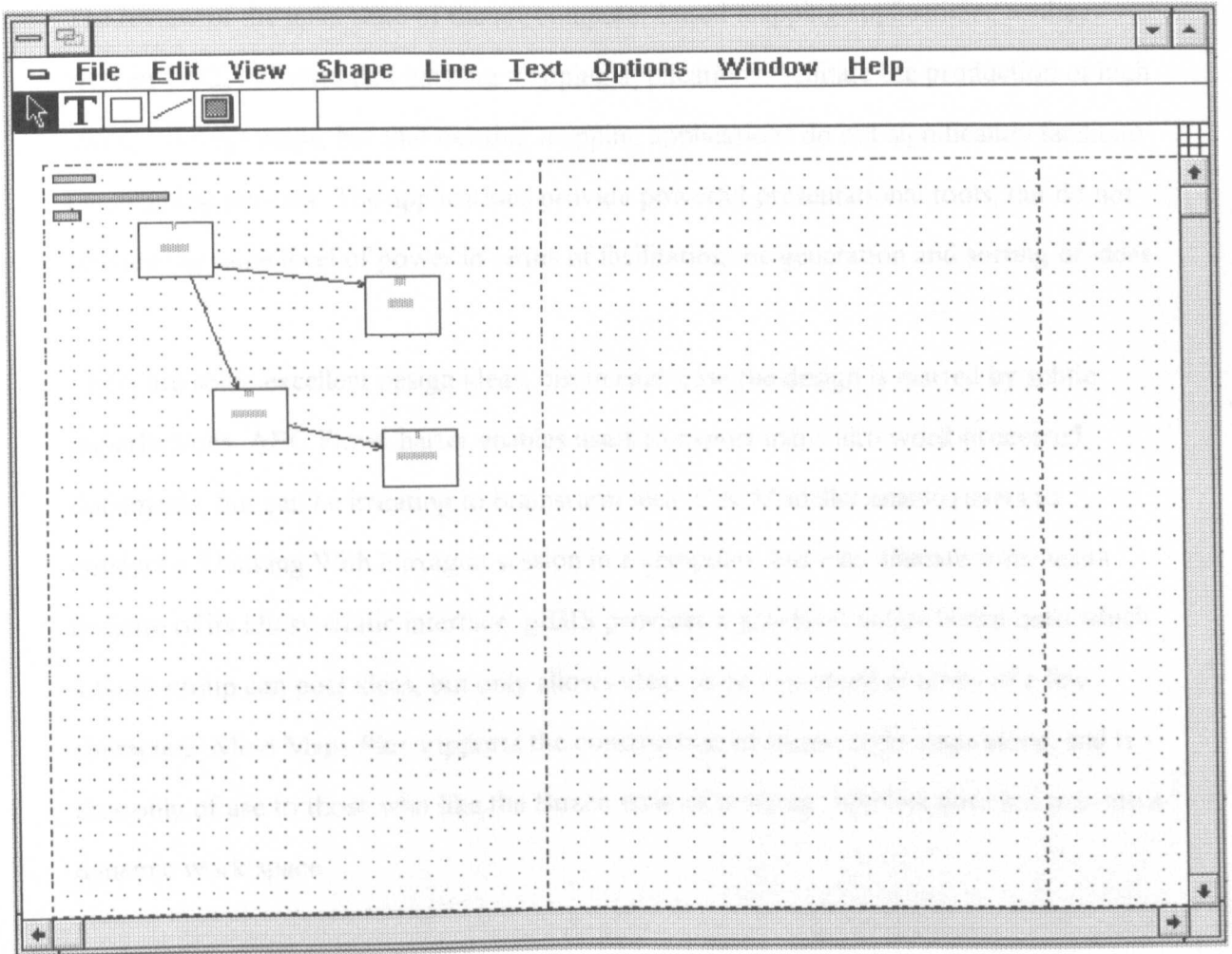


Fig 3.15: A screen shot showing ABC FlowCharter 1.13 with the view of the work space zoomed out



The difficulty provided by applications reviewed in this report is the application of computer-based modeling applications to the design of complex systems with product, and with the design of the system. The design process has been simplified.

In the light of the above, great effort is required in the design effort involved in increasing the meet the needs of the system.

## 3.4 Discussion

The review of the main state of the art computer-based mapping applications, as they were in 1992, indicates that existing mapping applications facilitate the production of high quality concept maps, but that existing mapping applications do not significantly facilitate the mapping **process**. The applications provide powerful presentational tools, but do not provide the same level of power in terms of facilitating the generation and sorting of ideas.

There are some excellent design ideas, but in each case the design is marred by subtle imperfections. ABC FlowCharter enables users to export maps into word-processed documents, but can be irritating to brainstorm into. C.K.Modeller enables users to conduct a Thinking With Hexagon session in a computer, but may alienate some users because of its idiosyncratic interface. gIBIS provides a graphical notice board onto which a work group can post ideas, but only allows ideas to be expressed in terms of a few characters. Mind Maps Plus supports the construction of Buzan style maps alone, and is thus only of use to those who like the Buzan style of working. SemNet does not provide a dynamic work space.

The facilities provided by applications reviewed in this chapter indicate that the designers of computer-based mapping applications have assumed that users are primarily concerned with product, and indicate that the needs of users who are primarily concerned with process have been neglected.

In the light of the above, it can be concluded that ways need to be found to reduce the effort involved in interacting with computer-based mapping applications, if they are to meet the needs of the majority of mappers. Thus, in so far as is possible:

- Ideas and links should take no more than a single mouse click or key stroke to enter.
- The work space should be uncluttered, so that ideas can be easily scanned.
- Mapping applications need to be programmed to interpret users' intentions and not require the user to have to keep selecting between tools.

## 3.5 Summary

Current computer-based mapping applications provide tools which support the *production* of a variety of map-like representations of thought. However, in terms of the *process* of generating, sorting and connecting ideas, as exemplified in the construction of concept maps, the facilities provided by current mapping applications are limited.

Current applications provide dynamic ideas boxes and dynamic links, and allow mappers to expand top level maps into a number of sub maps, but they are not ergonomically efficient. Too much of the potential work space is taken up with toolbars and menus, and brainstorming is interrupted by the mechanics of adding and editing new ideas and links.

It is clear from previous discussion that a subtle change in design can mean the difference between an application which encourages the generation, sorting and connecting of ideas, and an application which does not. It is therefore clear, that if an application is to be developed which fully supports the needs of those engaged in the construction of concept maps, then feedback needs to be elicited from those engaged in the construction of concept maps.

One way in which to elicit the feedback required is to develop a new computer-based mapping application, and to iteratively refine that application in the light of users' comments.

# Chapter Four

## Methodology

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## 4.1 Introduction

The discussion in previous chapters has provided a *framework* for understanding the issues which affect the utility of computer-based mapping applications. That framework indicates that there are three key issues to take into account when assessing the utility of a computer-based mapping application:

- whether the computer-based mapping application enables the mapper to make the most of the potential work space by minimising unnecessary menu bars, toolbars, and toolboxes;
- whether the computer-based mapping application provides a dynamic work environment; and,
- whether the computer-based mapping application enables ideas to be input with a minimum of mouse clicks or key strokes.

In this chapter a methodology is explained with which the framework may be refined. The methodology is based on the Adaptive Waterfall Model for Knowledge Acquisition. This chapter explains how the Adaptive Waterfall Model for Knowledge Acquisition was used to understand what kinds of facilities mappers wish computer-based mapping applications to provide, and in which circumstances it is desirable to use a computer-based mapping application, as opposed to an alternative mapping medium.

## 4.2 The nature of the research undertaken

The work presented in this thesis aims to bridge the divide between pure and applied research. The literature survey reported in chapter two and the practical work to be presented later have led to the development of a new system of classification, upon which future theoretical research might be based. The application of that classification has led to the development of working software and also of a checklist which might be used to evaluate computer-based mapping applications.

A still more precise description of this work can be given. Phillips and Pugh say in their guide to PhD research that :

Research has been traditionally classified into two types: pure and applied. But we find that this distinction - implying as it does that pure research supplies the theories and applied research uses and tests them out in the real world - is too rigid to characterise what happens in most academic disciplines, where, for example, 'real world' research generates its own theories and does not just apply 'pure' theories. We shall consider a threefold classification of research: exploratory, testing-out and problem solving. (Phillips and Pugh 1987 p46).

Phillips and Pugh describe *exploratory research* as that research which is involved in exploring a new issue or problem which others have not yet explored. The aim of exploratory research is to develop new concepts and theories, which may then be tested empirically at a later date. *Testing-out research* is defined as research which investigates the limits of previously established theories. Testing out involves the gathering of quantitative data with which to assess an existing theory. *Problem-solving research* is explained as research which starts from the point of view of a particular 'real world' problem and brings together a set of intellectual resources to solve that problem.

Using Phillips and Pugh's second definition, the work described in this thesis is *exploratory* and *problem-solving*. There was insufficient data with which to design a quantitative ('testing-out') investigation into user attitudes towards the facilities provided by computer-based mapping applications. For instance, a questionnaire approach would have floundered because:

- there was not enough existing literature with which to develop a credible questionnaire
- those computer-based mapping applications which were available all had problems associated with them (*as discussed in chapter three*)
- there was no information available relating to groups of potential respondents, to whom a questionnaire could have been sent.

Thus, in the absence of enough tangible concepts and theories to test quantitatively, the research reported in this thesis proceeds firstly on an exploratory basis. It:

- examines what can be usefully gleaned from existing research in *related* fields
- posits a description of the issues affecting the utility of computer-based mapping applications
- uses a qualitative research tool to refine that description.

In practical terms, the examination of existing research in related fields and the positing of a number of new concepts and theories has been completed in chapters two and three. The present methodology chapter will therefore focus on the use of a qualitative research tool (the Adaptive Waterfall Model) to refine a description of these new concepts and theories.

At this point, it can be noted that as a result of the application of the Adaptive Waterfall Model, the work described in this thesis falls secondly into the category of *problem-solving*. This categorisation can be made because the application of the Adaptive Waterfall Model led to a precise design specification for a computer-based mapping application, together with actual development of such an application: BrainBox (and its Macintosh cousin HyperMap).

## 4.3 The Adaptive Waterfall Model

The research tool chosen to explore the issues which affect the utility of computer-based mapping applications was the Adaptive Waterfall Model for Knowledge Acquisition. The Adaptive Waterfall Model was selected because it is a standard knowledge-elicitation methodology, with which knowledge engineers elicit domain knowledge from experts and the intended end-users of expert systems. It is a methodology explicitly focused on refining a knowledge engineer's understanding of the concepts and relationships which exist within the knowledge domain being investigated.

The Adaptive Waterfall Model (McGraw / Harbison-Briggs 1989) is based on the Phased Waterfall Model of software development (Royce 1970, Rosove 1967, Boehm 1981 in McGraw / Harbison-Briggs 1989), and is in effect an application of the Phased Model within the domain of knowledge engineering. In its simple form the Phased Waterfall Model has seven phases: (1) feasibility, (2) requirement analysis, (3) product design, (4) detailed design, (5) programming, (6) system integration, (7) implementation and maintenance. Although in theory each of these phases is sequential, in practice they operate in a series of feedback loops, so that as work in one phase is completed, it enables a re-evaluation of work completed in previous phases. If necessary that re-evaluation leads to modification. The re-evaluation process consists of **verification** that the product is built correctly, **validation** that the right product has been built, and **configuration management** to ensure that a definitive version of the product is capable of completion. In contrast to the seven stages of the Phased Model, the Adaptive Model has five main stages. As in the Phased Model, the completion of each stage provides for time to modify the work of previous stages, before continuation towards a subsequent stage.

The five main stages of the Adaptive Model are: conceptual analysis, domain analysis, structured interviews, solution analysis and prototyping. The **conceptual analysis** consists of seeking an understanding of the domain in question through background reading. The

background reading is used to help focus the engineer on the salient features of a task and helps to identify / develop an appropriate terminology for discussing that task. The **domain analysis** involves creating a working model of the task being investigated. Once a working model has been constructed for the domain being studied, **structured interviews** are used to identify the experts' view of the domain under investigation. Interviews may be used in combination with other techniques / tools, depending upon the domain under investigation. In the **solution analysis** phase, the knowledge engineer seeks to find out how the expert uses domain knowledge to solve problems. Finally, the **prototyping** stage involves the implementation of the knowledge base in the form of an expert system.

## 4.4 Applying The Adaptive Waterfall Model

In this thesis, the following tasks were undertaken, using the Adaptive Waterfall Model:

- **Conceptual analysis.** A review of the literature relating to mapping ideas (*see chapter two*), and a review of existing computer-based mapping applications (*see chapter three*), in order to determine:
  - what mappers are attempting to achieve through the visual representation of ideas
  - the processes undertaken while visually representing ideas
  - what mappers need in order to facilitate the process of visually representing ideas
  - how existing systems meet, or fail to meet, the mapping needs identified in the initial review of literature.
- **Domain analysis.** Based on the conceptual analysis, the development of a prototype computer-based mapping application called KwikSort (*see sections 4.5 below*).
- **Interviews.** Interviews with mappers during which the mappers commented upon the utility of KwikSort and enabled the software to be iteratively improved.
- **Solution analysis.** The use of formal interviews (*see section 4.7 below*) to discern how computer-based mapping applications might facilitate the mapping process.
- **Prototyping.** The development of the CBMA-Checklist (*see section 4.10 below*) to express the new concepts and theories developed during the course of the investigation, and the development of the BrainBox computer-based mapping application (*see section 4.10 below*) to demonstrate an implementation of these concepts and theories.

## 4.5 KwikSort

The literature and software reviews reported in chapters two and three of this thesis were used to develop a framework of understanding upon which the design of an efficient computer-based mapping application could be based. On the premise that the utility of a computer-based mapping application is relative to the extent to which it meets the mapping needs of those using the application, it was decided to employ a prototype mapping application to elicit feedback from mappers. A computer-based mapping application called KwikSort was designed. The purpose of KwikSort was to act as a research tool to elicit mappers' reactions relating to the issues affecting the utility of computer-based mapping applications.

The rationale for using KwikSort was that KwikSort would enable the framework developed in chapters two and three to be externalised/physicalised in a form which mappers could comment upon. The use of some form of physicalisation to explore a knowledge domain is often used in knowledge elicitation because it helps to focus responses of the interviewee. The utility of a physical model is underlined in a report by Humphreys, Oldfield and Allan (1987) in which it was found that the richest elicitation of knowledge comes not from unframed open-ended questions (such as 'What do you think about...') or framed closed questions (such as those found on many questionnaires), but from questions which are open and framed in terms of real or imagined experiences with which the interviewee can identify. By allowing mappers to use a prototype mapping system and to comment on the strengths and short-comings of that system, the mapper was given relative freedom to answer, but had a tangible experience to help focus and coalesce their thoughts. In addition, in response to the mappers' feedback the system was modified, and could thus be used to elicit further criticism. This modification was enabled by choosing to implement KwikSort in a fast prototyping language called PLUS PPL.

Given the conclusions of the literature review, it was decided that KwikSort would focus on providing an environment in which mappers might concept sort, and should they wish, convert the results of their concept sorting into a concept map.

The decision to focus on concept sorting was taken because the literature review indicated that the design of a concept sort is 'foundational', in that all other kinds of map can be formed by editing the results of a concept sort. The decision to focus on the concept map was the result of the literature review indicating that editing a concept sort into the form of a concept map is the best trade-off between effort and the kind of product which would enable mappers to achieve most of their mapping goals.



## 4.6 Investigation One - Informal interviews

Feedback from an increasing number of mappers was used to drive the development cycle of KwikSort. At the end of each cycle the framework relating to what constitutes an efficient computer-based mapping application was updated, and the software modified in accordance with those updates. The majority of feedback was informal. The feedback was derived by demonstrating KwikSort to a number of mappers and noting their reactions, and by allowing a number of mappers to have some limited *hands-on* experience of the software. Most of the mappers who provided feedback were busy people, and so initial feedback was provided on an informal basis, so that the mappers would not be discouraged from remaining in the test program. The use of informal feedback worked well. By minimising demands on the mapper's time, and by enabling mappers to see their comments actually affecting the development of the software, it allowed many mappers to become more deeply involved in the test program. Most became more considered in their opinions, and better at articulating their thoughts regarding computer-based mapping in general and regarding KwikSort in particular.

## 4.7 Investigation Two - Structured interviews

Twenty-one mappers were given several weeks to evaluate KwikSort Version 1.5. These mappers were then questioned, using the interview structure outlined in **Fig 4.1**. The structure of the interview was derived from the informal comments made by users during the development of KwikSort. Throughout each interview, the author tried to make it clear that he was interested in discerning KwikSort's weaknesses as well as the strengths, so that users would feel able to provide both positive and negative criticism. As each interview progressed, written notes were taken. The background information derived from these notes is summarised in a textual form in Chapter Six of this thesis, and the detailed information is collated in a set of tables in Chapter Seven.

## 4.8 The users

The users who were asked to comment on KwikSort came from a wide variety of backgrounds. This diversity of backgrounds is illustrated by **Fig 4.2**, which provides an overview cross-referencing users with details relating to their profession and their levels of computer literacy. To assess computer literacy, each user was asked to list the computer packages with which they were familiar. Knowing a DOS program was 'worth' one point, and knowing a Windows or Mac program was 'worth' three points. Having totalled each person's points, users with less than three points were rated 'low', users with four to six points were rated 'medium', whilst users with more than six points were rated 'high'. The one dimension in which users were most similar was that (in the main) users were successful, intelligent and highly able, coming from higher education and from management positions in business.

## 4.9 Collating the feedback

The notes during the interviews with users are reported in two ways in Chapter Six of this thesis. Firstly, a general overview of the interview is reported, so that it is possible to gain an impression of the user's reactions towards computer-based mapping and towards KwikSort as an example of a computer-based mapping application. Secondly, a number of specific details are collated, to look for patterns within the interview data. These patterns are then used as the basis for a number of conclusions relating to the issues which affect the utility of computer-based mapping applications. These conclusions relate to identifying the kinds of people who might find a computer-based mapping application useful, identifying the design features which enhance the utility of computer-based mapping applications, and identifying how those design features should be implemented.

**Fig 4.1: The interview structure used when asking people for their reactions to KwikSort  
1.5**

**Question 1**

(Before using KwikSort) Which techniques did the user implement maps with?

**Question 2**

(Before using KwikSort) What were the benefits, which the user associated with mapping?

**Question 3**

What were the main benefits and difficulties that the user found  
(when comparing computer-based mapping with non computer-based mapping)?

**Question 4**

Which aspects of KwikSort did the user like/dislike? And, Why?

**Question 5**

Does the user hope to use KwikSort in the future?

**Question 6**

Has using KwikSort changed the user's attitude towards mapping in general?

**Fig 4.2: A table cross-referencing users with the versions of KwikSort they used, along with the users' levels of computer literacy**

User	Background	Ver 1.0	Ver 1.1	Ver 1.3	Ver 1.4	Ver 1.5	Computer Literacy
User A	Designer				✓	✓	High
User B	University Lecturer			✓	✓	✓	High
User E	Business Manager			✓	✓	✓	High
User G	Business Consultant			✓	✓	✓	High
User H	Post Grad Student				✓	✓	High
User I	University Professor			✓	✓	✓	High
User J	Post Grad Student				✓	✓	High
User L	Software Developer		✓	✓	✓	✓	High
User M	Computer Consultant		✓	✓	✓	✓	High
User N	English Teacher				✓	✓	High
User O	I.T. Teacher.				✓	✓	High
User Q	I.T. Teacher		✓	✓	✓	✓	High
User R	University Professor			✓	✓	✓	High
User T	Post Grad Student				✓	✓	High
User V	Yr. 4 Business Under Grad	✓					High
User W	Yr. 4 Business Under Grad	✓					High
User X	Yr. 4 Business Under Grad	✓					High
User Z	Quality Manager				✓	✓	High
User ZC	Systems Analyst		✓	✓	✓		High
User C	Educator For Tear Fund					✓	Low
User D	Social Worker					✓	Low
User F	PGCE Student				✓	✓	Low
User K	Educator				✓	✓	Low
User P	English Teacher				✓	✓	Low
User U	Church Leader				✓	✓	Low
User Y	Nurse	✓					Low
User ZA	PGCE Student	✓					Low
User S	Yr. 1 Under Grad		✓	✓	✓	✓	Medium
User ZB	Yr. 4 Business Under Grad	✓					Medium
User ZD	Yr. 4 Business Under Grad	✓					Medium
	Number of users...	7	5	10	21	24	

*(Not all users used every version of KwikSort. This table indicates who provided feedback, and upon which version of KwikSort they commented).*

## 4.10 Outcomes

The results of the interviews were collated and discussed. This discussion was then used as the basis for the development of the Computer-Based Mapping Application Checklist (CBMA-Checklist). The checklist was designed so that mappers' needs might be expressed in a form which those needing to review the utility of computer-based mapping applications would find useful. In addition, using the CBMA-Checklist, two mapping applications - BrainBox and its Macintosh cousin HyperMap - were developed to act as knowledge elicitation tools by future researchers and to act as mapping media for those who want to engage in computer-based mapping. BrainBox was implemented in the Visual Basic programming language under Windows 3.1 on the PC, while HyperMap was implemented in HyperCard 2.0 on the Macintosh.

## 4.11 Summary

The Adaptive Waterfall Model for Knowledge Acquisition was used to provide a framework around which the work reported in this thesis was conducted. A literature review gave rise to a model of how a computer-based mapping application might be used to facilitate the work of mappers. A prototype mapping application was developed and tested. As a result of informal feedback from mappers, the prototype was iteratively improved. When there was a consensus that the software had reached a level of maturity, twenty-one mappers were asked to comment in depth on the utility of KwikSort, and upon how the use of a computer-based mapping application might impact on their work. Those comments were then collated, and used to develop the CBMA-Checklist. Based on the checklist, a new mapping application called BrainBox was devised on the PC and a mapping application called HyperMap was developed for the Macintosh.

# Chapter Five

## Investigation One

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# 5.1 Introduction

This chapter describes the main design features in each version of the KwikSort program, users' reactions to these design features, and changes made in response to users' reactions.

Each version of KwikSort is described, indicating what the software was seeking to achieve. Particular features of note are explained, showing how problems inherent in previous versions of KwikSort had been addressed. Users' reactions to the changes are discussed and recommendations made on how future versions of KwikSort might be improved.

Finally, four figures are presented to summarise the main features of KwikSort in a visual format, making it easier to see how the program evolved over time.



## 5.2 KwikSort Ver 1.0

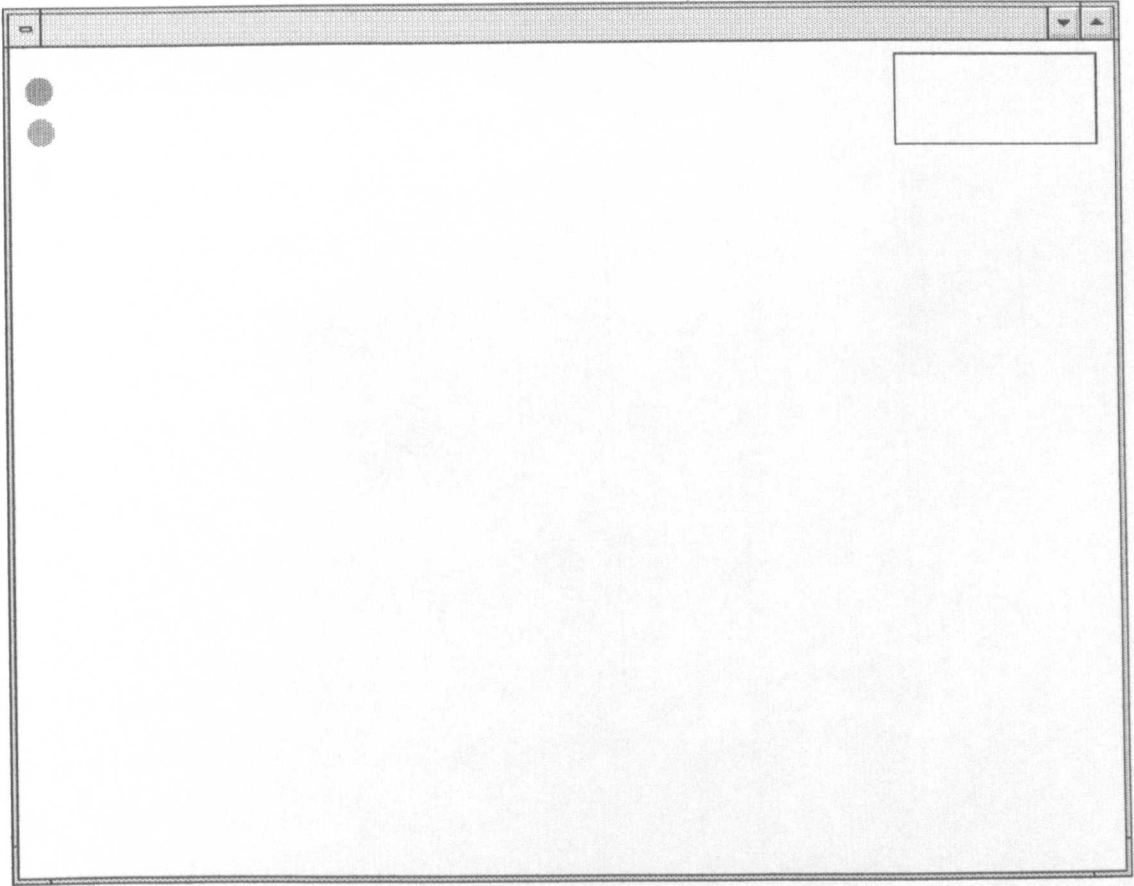
The aim of KwikSort was to provide would-be mappers with a dynamic environment in which mappers could concept sort and add lines to that concept sort, with a minimum of effort. To achieve the stated aim, KwikSort was provided with a work area and the facility to input ideas into separate ideas boxes. Those ideas boxes were stored at the top right of the screen and could be dragged around the map surface using a mouse (see Fig 5.1). To maximise the work area, KwikSort provided all menu options via two pop-down menus. Menu options were provided for inputting ideas, altering the font, colour and style of ideas boxes and the text within them. With regard to inputting ideas, it became evident that too many mouse actions were required to select a box from the pile of ideas boxes, drag that box onto the work space, and then input text. To reduce the number of mouse actions, a pop-up brainstorm dialogue was provided. Any idea typed into the dialogue could be copied to the map surface with a press of the return key (Fig 5.2). Finally, KwikSort provided a set of bit-mapped paint tools with which to draw lines between boxes.

The decision to use bit-mapped lines, as opposed to vector-based lines, was forced on KwikSort by the constraints of the PLUS programming language in which KwikSort was implemented. Chosen because it was a HyperCard clone, capable of operating in both PC and Apple Macintosh environments, PLUS originally appeared to be an ideal prototyping tool. The nearest contender, Asymmetrix Toolbook had (at that time) a reputation for being even slower, while languages such as C or C++ were notoriously difficult to program in. However, fast prototyping was bought at a price. The system requirement of the PLUS language, and the instability of the original version of the language, forced a number of compromises in the system design. Those who are acquainted with PLUS know that it requires (what in 1992 was) a high-specification computer. In PC terms, the specification was a 25 MHz 386 with 4 meg of RAM. Although vector-based graphics

were available, they slowed PLUS down significantly if more than a few lines were drawn on any one map.

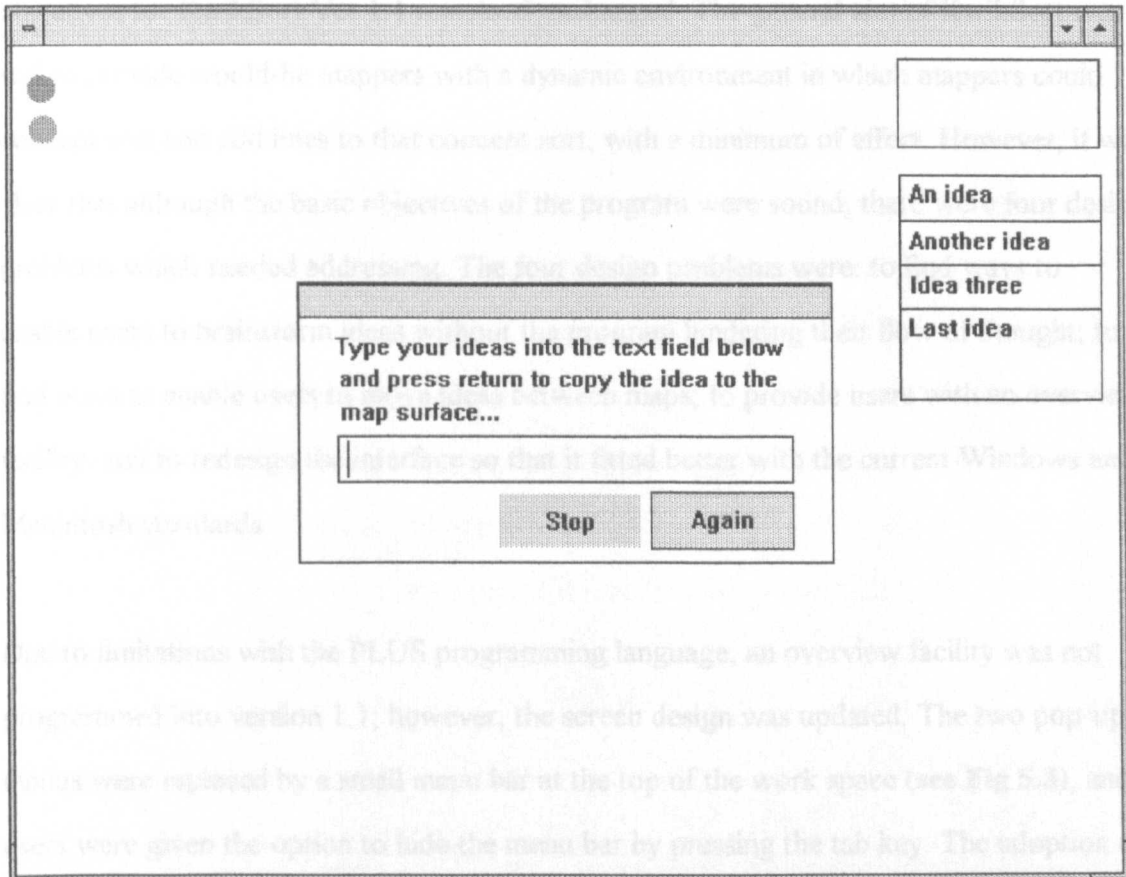
Feedback from those who used KwikSort was clear. Users liked the analogy with concept sorting on a table top, but found the design of KwikSort flawed in four important ways. Firstly, KwikSort was too slow on all but the fastest computers, which disrupted the user's 'flow of thought'. A wait of even a fraction of a second was frustrating to a user wanting to brainstorm a number of ideas. Secondly, there was no overview function, so that only part of the A4 work space could be seen at any one time. Thirdly, there was no easy way to import and export ideas, which meant that once ideas had been typed onto a map they were trapped on that map, and it was not possible to move an idea from one map and place it on another map. And fourthly, it became apparent that users did not like the aesthetics of the original work space. Watching a few users, it became evident that although the two small buttons might have maximised the work area, they also detracted from the user's concentration, by requiring the users to remember which menu options were available under which menu button. The screen design was too non-standard, at a time when the Windows and Macintosh operating systems were encouraging greater uniformity between applications.

**Fig 5.1: A screen shot of the work space provided by KwikSort 1.0**



*NB: Note the use of pop-up menus which were activated by clicking on the two buttons on the far left of the screen.*

Fig 5.2: A screen shot of the pop-up brainstorm menu provided by KwikSort 1.0



*NB: Note that the user typed ideas into the dialogue, and pressed return, to have the idea copied to an ideas box on the far left of the screen. Each box arranged itself slightly below the previous box, as shown in the figure above.*

## 5.3 KwikSort Ver 1.1 / 1.2\*

\* Version 1.2 being a bug fix for version 1.1

As a result of user feedback gained from KwikSort Version 1.0, the initial design objectives for KwikSort Ver 1.1 remained unchanged. The general aim of KwikSort was still to provide would-be mappers with a dynamic environment in which mappers could concept sort and add lines to that concept sort, with a minimum of effort. However, it was clear that although the basic objectives of the program were sound, there were four design problems which needed addressing. The four design problems were: to find ways to enable users to brainstorm ideas without the program hindering their flow of thought; to find ways to enable users to move ideas between maps; to provide users with an overview facility; and to redesign the interface so that it fitted better with the current Windows and Macintosh standards.

Due to limitations with the PLUS programming language, an overview facility was not programmed into version 1.1; however, the screen design was updated. The two pop-up menus were replaced by a small menu bar at the top of the work space (see Fig 5.3), and users were given the option to hide the menu bar by pressing the tab key. The adoption of the menu bar simplified the menu structure, because it allowed menu options to be divided into logical groups (which had not been possible with the previous screen design, because PLUS did not support sub-menus).

With respect to the generation of new ideas and the facility to move ideas between maps, three new features were developed. There were: *note pads*, *autowrite facility*, and *sort cards*. Each map was given its own note pad (see Fig 5.4). The note pad consisted of a single word-processor field, onto which people could quickly brainstorm their ideas. The design of the note pad allowed users to input ideas as if brainstorming into a word processor, without having to wait even a fraction of a second for the pop-up brainstorm

dialogue to refresh itself. The use of the note pad provided a place to brainstorm ideas away from the map surface, thus leaving more space in which to sort ideas.

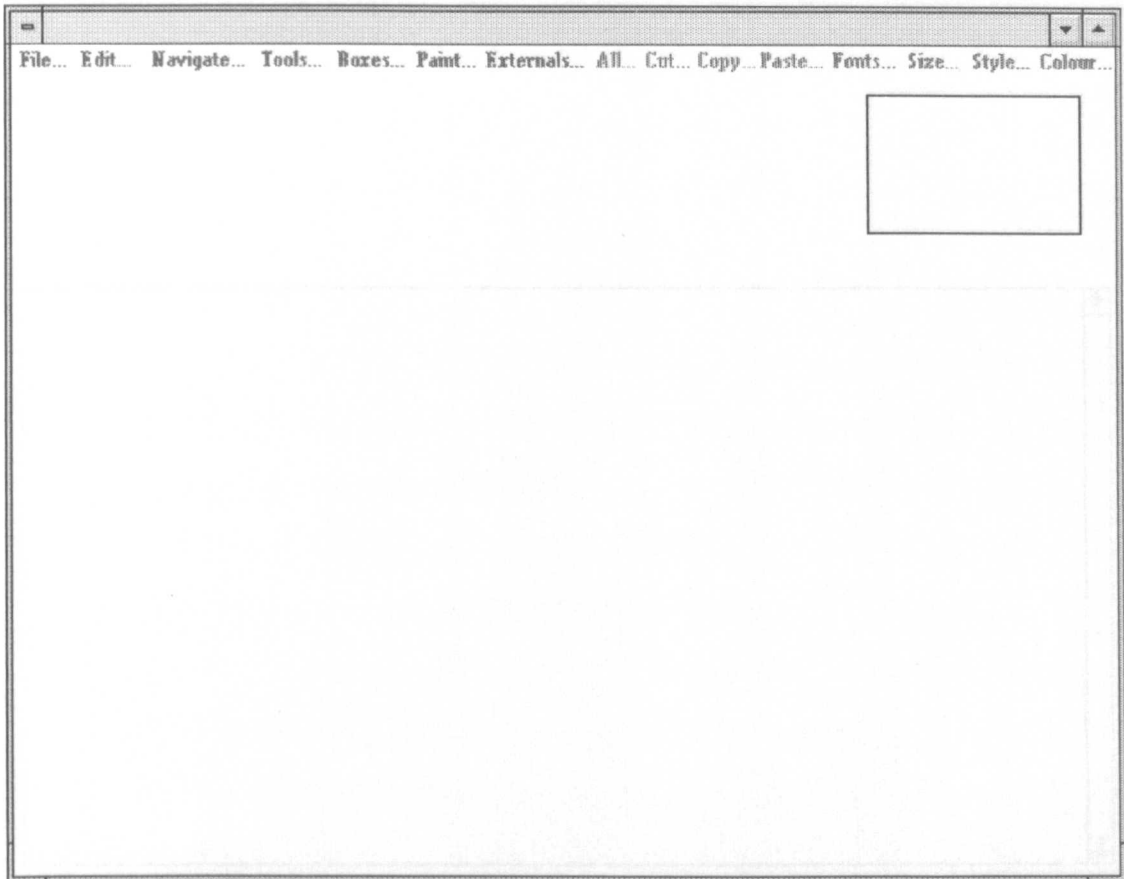
However, advantageous though the note pad was, it provided a new problem to be solved - how to copy ideas from the note pad to the map surface, without involving the user in expending yet more time and effort. The solution was found in the form of the autowrite facility. The autowrite facility enabled a block of text typed onto the note pad to be converted into a number of separate ideas on the map surface. To do this, it was decided that each paragraph of text (that is text separated by a hard return, as opposed to a soft return) on the note pad would be copied into a separate ideas box on the map surface, and that the boxes would be placed in the top right corner of the map. Added sophistication to this arrangement was made by allowing users to choose whether to autowrite all the text on the note pad, or whether to autowrite a highlighted selection of text only, and by allowing users to choose whether to have KwikSort fan the ideas rather than pile the ideas in a single heap.

The adoption of the note pad provoked the idea that users might want to map large subject domains or even import ideas from another program, for instance from a word processor or data base. In response to this perception, the sort cards were developed. A sort card was an extension to the note pad. It provided a separate work area onto which users could brainstorm or paste a large number of ideas, in a list format. Each sort card had three word processor fields in addition to a note pad (see **Fig 5.5**). The three fields could be used to pre-sort a large number of ideas before sorting these same ideas graphically on a map (or number of maps).

In the event, the re-design of KwikSort was only a partial success. Users appeared to find the aesthetics of the screen layout more to their liking, and found it easier to brainstorm and sort ideas. They appreciated the ability to keep brainstormed ideas away from the map surface until it was time to sort those ideas. However, the sort cards were not successful.

Many users appeared confused with regard to the function of the sort cards, and most ignored them, preferring to work in a *cycle* of brainstorm...sort... brainstorm...sort, rather than in a *progression* of brainstorm...sort..., in which only a few ideas are added after the initial brainstorming session. Despite the reservations expressed towards the sort cards, the success of the note pads and autowrite facility made more people enthusiastic about using a computer-based mapping application. However, as users began to generate more ideas, there was an increased pressure to find ways to move ideas more easily between maps. Users found cutting and pasting too lengthy a process, and tended to prefer to re-type ideas.

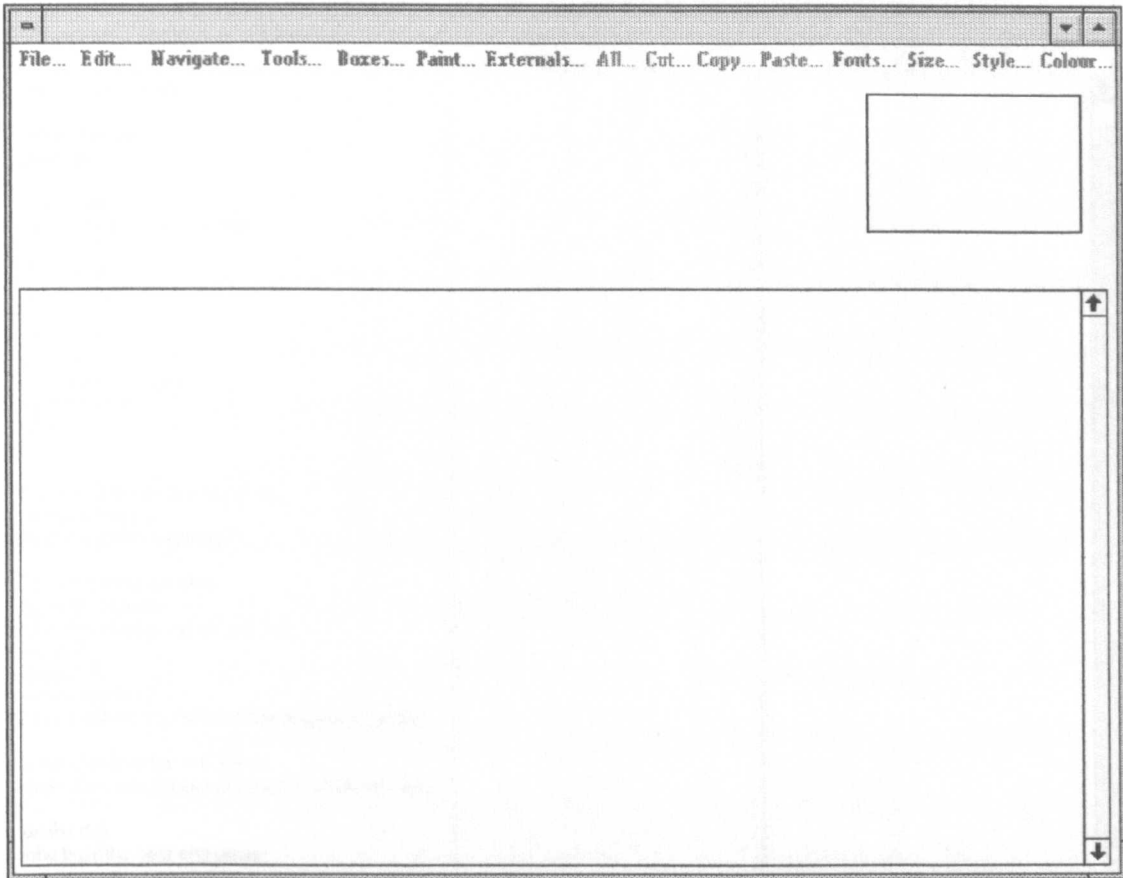
**Fig 5.3: A screen shot of the new work space provided by KwikSort 1.1/1.2**



*NB: Note that the two press buttons which were used to access pop-up menus have been replaced by a text-based menu bar. Using the tab key the menu bar can be hidden or made to reappear, and so screen space is still conserved, but the menu structure is at the same time made much more intuitive.*

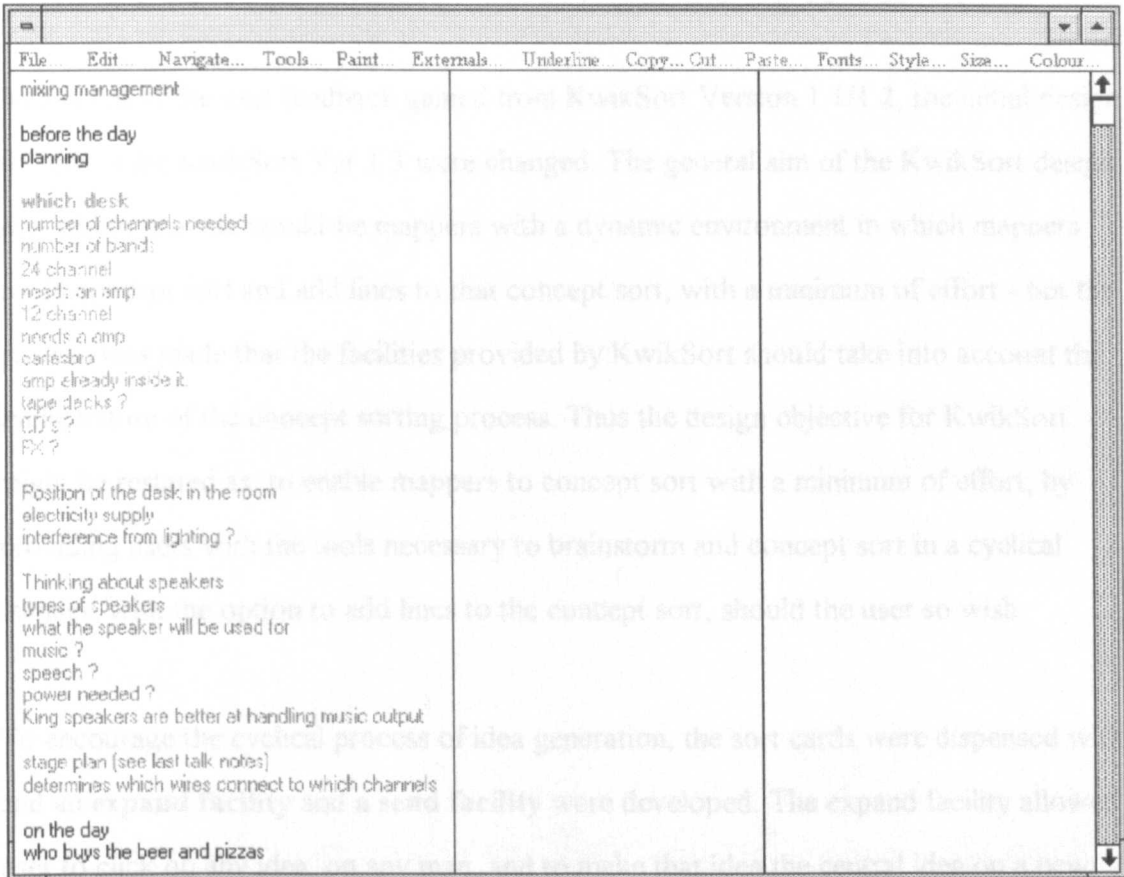


**Fig 5.4: A screen shot of the note pad provided by KwikSort 1.1/1.2**



*NB: The large text field which fills the bottom two-thirds of the screen is a note pad, which may be toggled on or off, onto which ideas may be brainstormed. An autowrite facility enabled ideas stored on the note pad to be copied to the map surface, or ideas on the map surface to be appended to the text on the note pad.*

**Fig 5.5: A screen shot of the sort card provided by KwikSort 1.1/1.2**



Instead of mapping in two dimensions, the work space became malleable in a finite number of directions within the electronic space found within the computer. The NB: Note that the user could choose to have between one and three sort columns, and also had access to a note pad similar to the one shown on the previous page. To make the process of sorting as simple as possible, cut, copy and paste options were a single mouse click away, and the user was able to use different fonts and colours to differentiate ideas.

Furthermore, appending the sort ideas to the end of the note pad on the receiving map. The feedback relating to the expand facility was very favourable. Users reported finding KwikSort more useful and intuitive to work in. Unfortunately, the same positive response was not to be found for the send facility. With hindsight this would not have been surprising, because users were more likely to want to receive ideas, than to send them. Thus, the send facility did nothing to alleviate the problem of ideas being stored on one map, whilst being required by a user working on another map. The feedback underlined the fact that users like to have all their ideas "in hand" at all times, and that having ideas

## 5.4 KwikSort Ver 1.3 / 1.4\*

\* Version 1.4 being a bug fix for version 1.3

As a result of the user feedback gained from KwikSort Version 1.1/1.2, the initial design objectives for KwikSort Ver 1.3 were changed. The general aim of the KwikSort design was still to provide would-be mappers with a dynamic environment in which mappers could concept sort and add lines to that concept sort, with a minimum of effort - but the proviso was made that the facilities provided by KwikSort should take into account the cyclic nature of the concept sorting process. Thus the design objective for KwikSort might be restated as: to enable mappers to concept sort with a minimum of effort, by providing users with the tools necessary to brainstorm and concept sort in a cyclical manner, with the option to add lines to the concept sort, should the user so wish.

To encourage the cyclical process of idea generation, the sort cards were dispensed with, and an **expand facility** and a **send facility** were developed. The expand facility allowed a user to click on any idea, on any map, and to make that idea the central idea on a new map. Instead of mapping in two dimensions, the work space became extendible in a infinite number of directions within the electronic space found within the computer. The expand facility actively encouraged users to think associatively, while the send facility supported the generation of new maps by enabling users to send ideas from one map card to another, appending the sent ideas to the end of the note pad on the receiving map.

The feedback relating to the expand facility was very favourable. Users reported finding KwikSort more useful and intuitive to work in. Unfortunately, the same positive response was not to be found for the send facility. With hindsight this should not have been surprising, because users were more likely to want to receive ideas, than to send them. Thus, the send facility did nothing to alleviate the problem of ideas being stored on one map, whilst being required by a user working on another map. The feedback underlined the fact that users like to have all their ideas "to hand" at all times, and that having ideas

spread between different maps effectively traps those ideas. It became evident that the key to freeing ideas was to create some way in which ALL the user's ideas were accessible from ALL the maps.

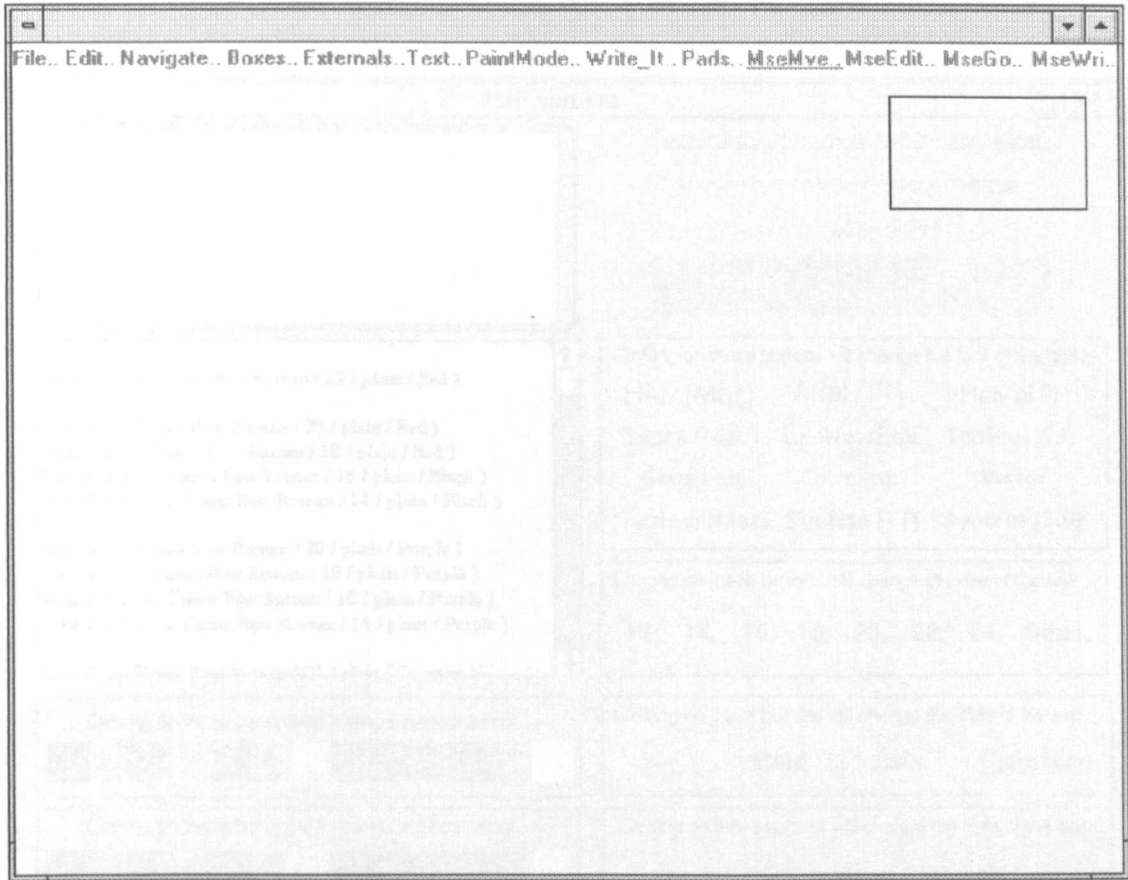
## 5.5 KwikSort Ver 1.5

KwikSort 1.5 was the final iteration of the KwikSort program, and was the program used to obtain more formal feedback from users. The aims and objectives of the program remained unchanged from KwikSort version 1.4. To recap, they were to enable mappers to concept sort with a minimum of effort, by providing users with the tools necessary to brainstorm and sort ideas in a cyclical manner, with the option to add lines to the concept sort, should the user so wish. In design terms the essential differences between Version 1.5 and Version 1.4 were twofold - the note pad system was re-designed to make all note pad text accessible at all times, and the menu layout was rearranged to be more ergonomically efficient (see Fig 5.6).

Inspired by the design of a number of word processors, users were given the option to pre-define a set of styles (see Fig 5.7) rather than defining font, size, back colour, and fore colour using individual menu choices. As a result, space became free on the menu bar, which allowed the *mouse means* options to be made more accessible. The mouse means options enabled users to inform KwikSort how they wanted a mouse down action on a box to be interpreted - whether the user wanted KwikSort to allow them to move the box, to edit the text in the box, or to activate a hypertext link associated with the box.

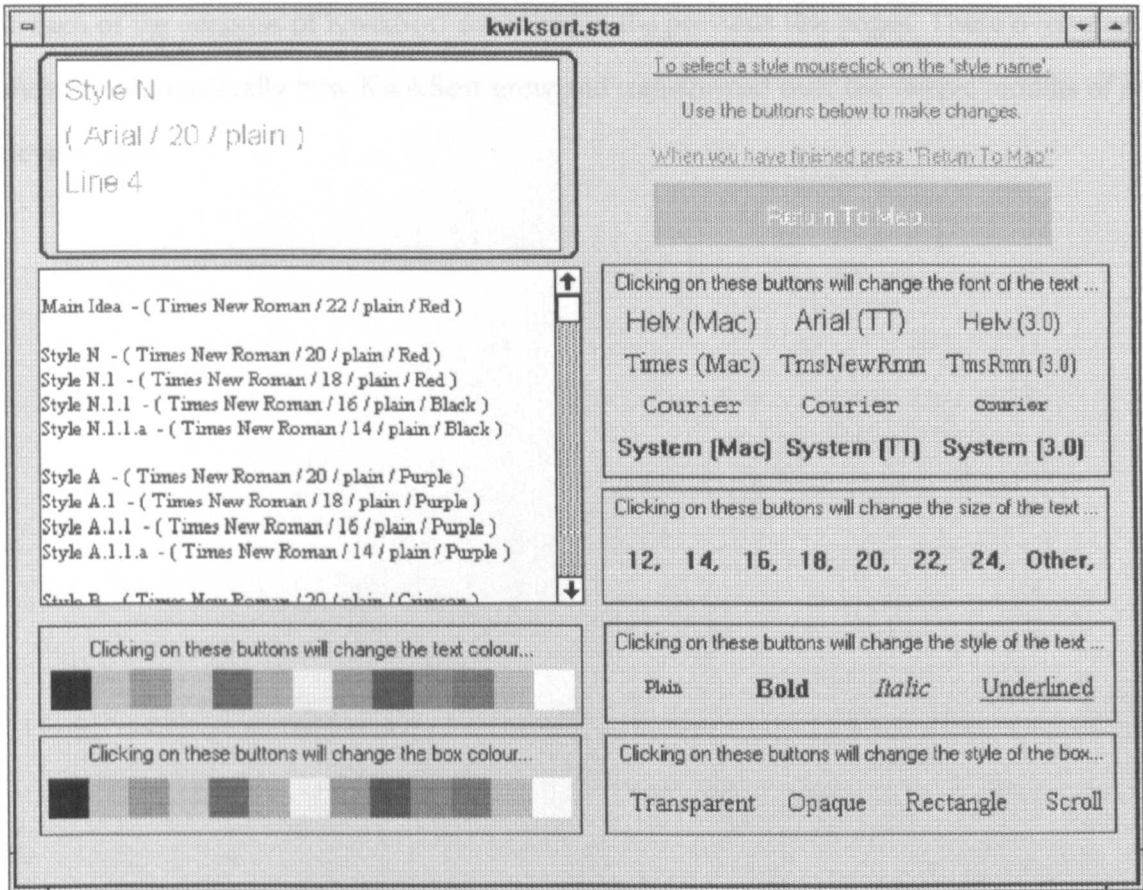
Two changes were made to the note pad system to facilitate access to ideas. The main change was a conceptual shift away from the idea of a note pad on each map, to the idea of a central note pad accessible from each map. The second change was to increase the number of pads from one to three. The practical effect of the change was that users now had access to all their ideas, no matter which map they were working on, and yet at the same time had the flexibility to decide which ideas should be stored on which pad. The informal reactions to these design changes were very encouraging, and suggested that KwikSort was now in a state where it would be appropriate to seek more formal feedback.

Fig 5.6: A screen shot of the new menu options in KwikSort 1.5



NB: Of particular note in the new menu layout is the way in which the mouse mode can be changed with a single mouse click, and the way in which the currently selected mouse mode is underlined. The inspiration for this layout was derived from the graphics applications available at the time (such as Corel 2.0 and Arts & Letters), which allowed users to select a tool, which would then define how an object behaved when the user selected that object.

**Fig 5.7: A screen shot of the pop-up dialogue allowing users to pre-define text and box style**



*NB: The user would select a style heading from the box on the mid left of the screen, for instance. The current style defaults for that heading would then be displayed in the text field on the top left of the screen. By pressing the various buttons and options changes could be made to the size, font, style and colour of the font and the ideas box.*

## 5.6 An overview

Figs 5.8 to 5.12 present a series of pictorial overviews which summarise the main facilities in each of the versions of KwikSort described in the previous few pages. These overviews show more graphically how KwikSort grew and transformed over the twelve months of its development.



Fig 5.8: A pictorial representation of the design of KwikSort 1.0

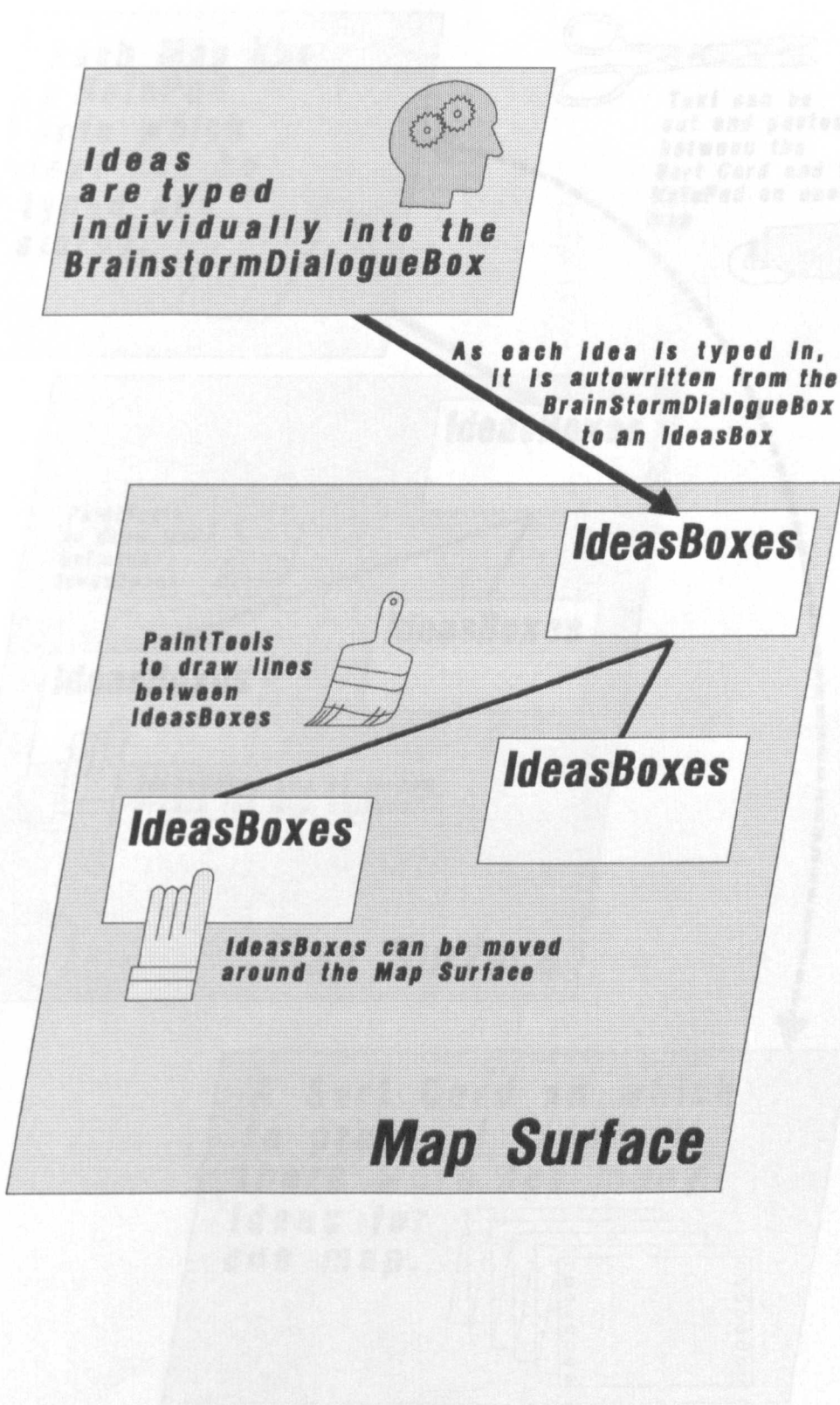


Fig 5.9: A pictorial representation of the design of KwikSort 1.1 / 1.2

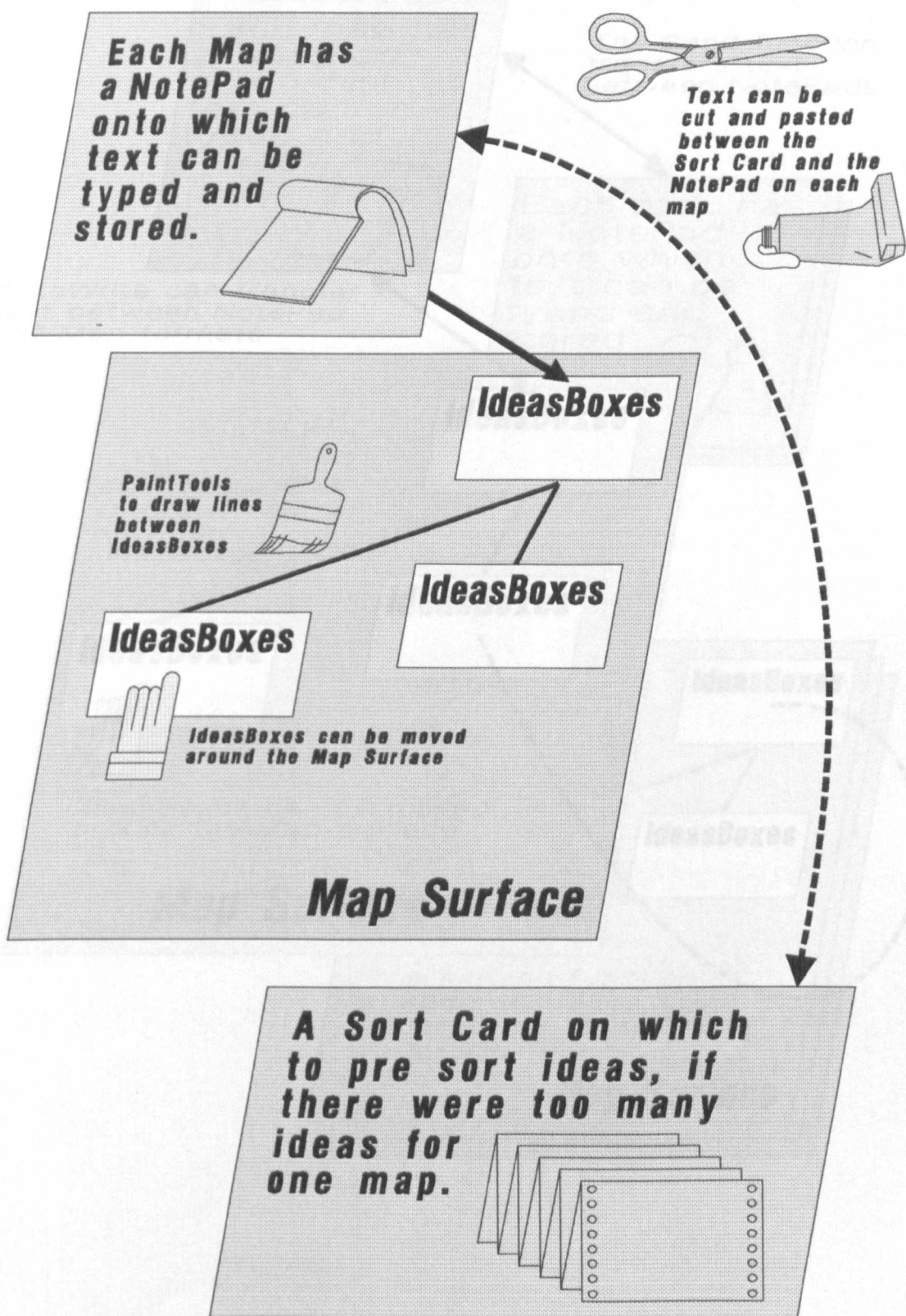


Fig 5.10: A pictorial representation of the design of KwikSort 1.3 / 1.4

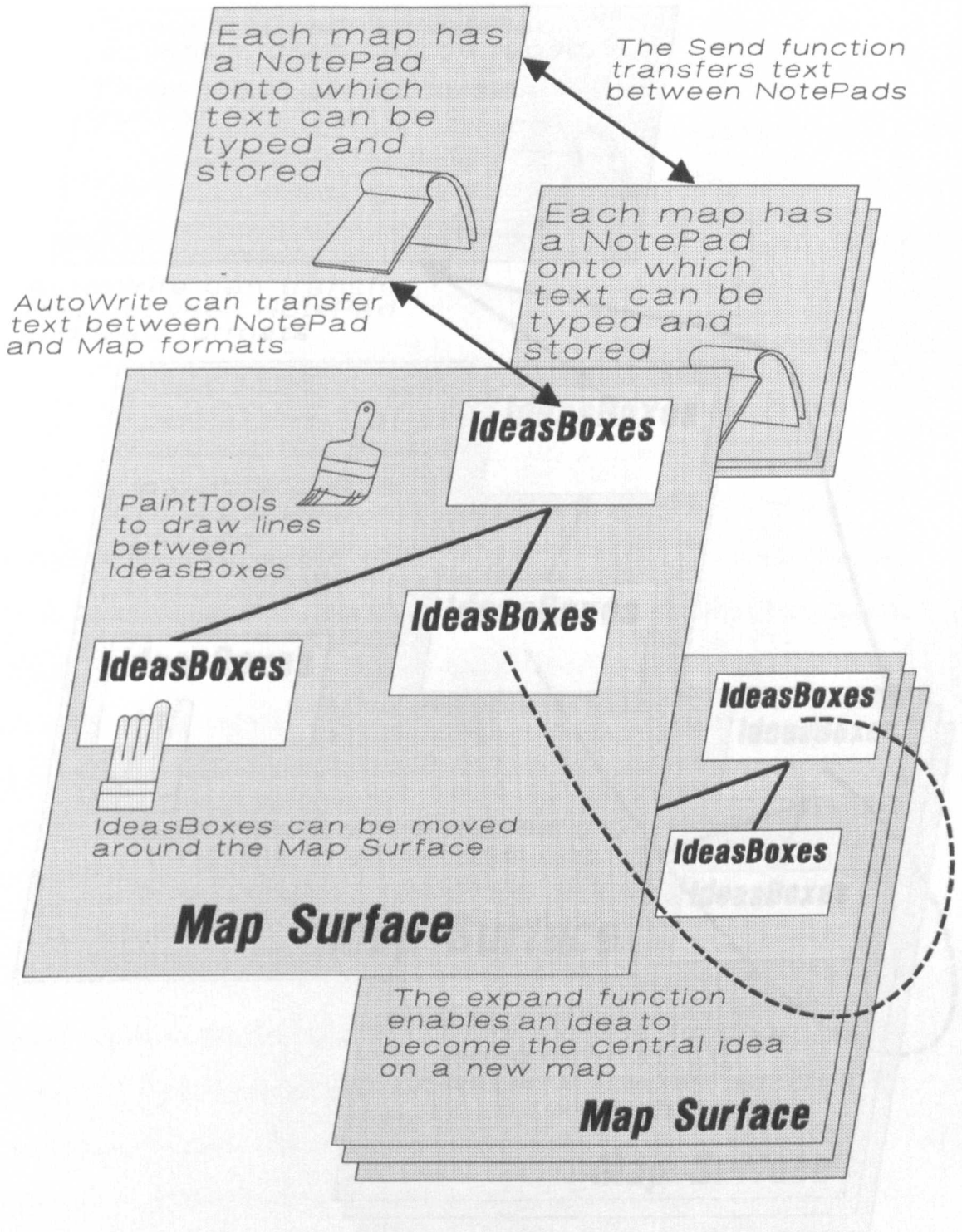
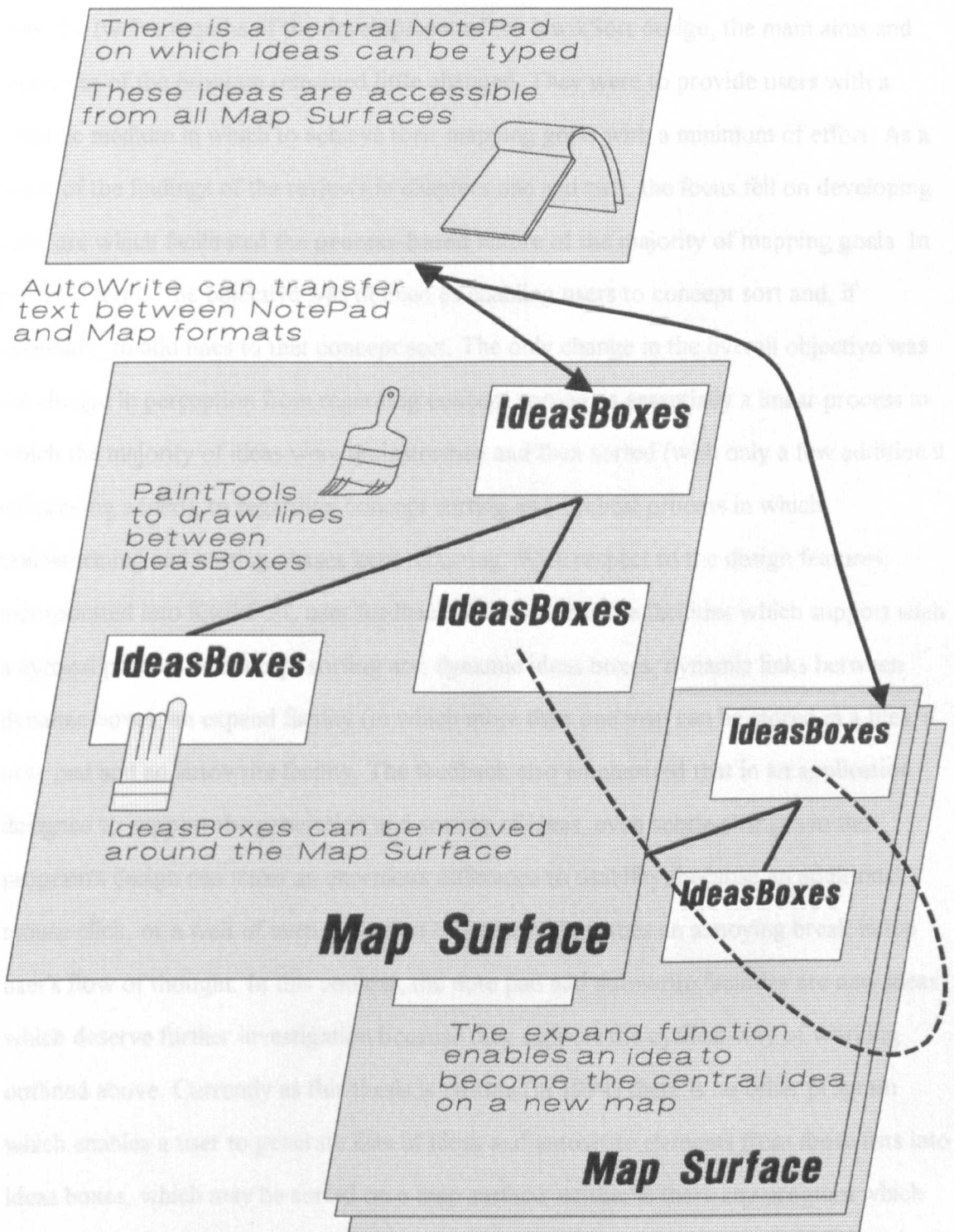


Fig 5.11: A pictorial representation of the design of KwikSort 1.5



## 5.7 Summary

Over the twelve months of the development of the KwikSort design, the main aims and objectives of the program remained little changed. They were to provide users with a dynamic medium in which to achieve their mapping goals with a minimum of effort. As a result of the findings of the reviews in chapters one and two, the focus fell on developing software which facilitated the **process-based** nature of the majority of mapping goals. In practical terms, the objective was defined as enabling users to concept sort and, if necessary, to add lines to that concept sort. The only change in the overall objective was the change in perception from regarding concept sorting as essentially a linear process in which the majority of ideas were brainstormed and then sorted (with only a few additional ideas being added), to regarding concept sorting as a cyclical process in which brainstorming and sorting phases kept recurring. With respect to the design features, incorporated into KwikSort, user feedback indicated that the facilities which support such a cyclical process of concept sorting are: dynamic ideas boxes, dynamic links between dynamic boxes, an expand facility (in which more than one map can be stored in a file), a note pad and an autowrite facility. The feedback also emphasised that in an application designed to support the generation and sorting of ideas, even subtle changes in the program's design can make an enormous difference to usability, because an additional mouse click, or a wait of even a fraction of a second becomes an annoying break in the user's flow of thought. In this context, the note pad and autowrite facilities are new ideas which deserve further investigation because they support the cyclical way of working outlined above. Currently as this thesis is written (in 1994) there is no other program which enables a user to generate lists of ideas and autowrite elements from those lists into ideas boxes, which may be sorted on a map surface; neither is there any program which enables mappers to click on ideas and have those ideas autowritten back into a list format.

# Chapter Six

## Investigation Two

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## 6.1 Introduction

In this chapter, the findings from the second investigation into users' perceptions of KwikSort are presented. The chapter is split into three main sections, which are outlined below.

Section 6.2 presents a summary of the notes taken during each of the interviews with KwikSort users. Of particular interest is the way in which the summaries provide an insight into how the mapping process can be experienced. Sometimes the mapping process is experienced as providing the mapper with a form of *mental scaffolding*, enabling the mapper to generate ideas and explore how these ideas relate to one another. At other times, the mapping process is experienced as providing the mapper with an *aide-memoir*, a way to externalise sets of ideas and relationships which the mapper has already pre-formed in their mind's eye.

Section 6.3 highlights patterns which emerged from the interview feedback. The tables presented show that the way in which a user wishes to interact with a computer-based mapping application determines whether that user will find use of a computer-based mapping application beneficial. In all, two ways of constructing concept maps became apparent. The two mapping protocols are termed **organic**, in which a user brainstorms and sorts a few ideas at a time (in a cyclic manner), and **disclosure**, in which the mapper prepares a map in their mind's eye, then externalises that map quickly, before the image of the map is lost from working memory. On the whole, those utilising an organic protocol *liked* using a computer-based mapping application, providing certain core tools were present, whereas those utilising a disclosure protocol *disliked* using a computer. Mappers utilising a disclosure protocol reported that use of computer-based media disrupted their flow of thought.

Finally, in section 6.4 the results reported in sections 6.2 and 6.3 are summarised, providing a foundation for the discussion of results in chapter seven.



## 6.2 Interview notes

Twenty-one users were interviewed about their perceptions of KwikSort. They are labelled User A to User U. The interviews are summarised below.

### 6.2.1 User A

**Background:** Self employed designer / multi-media author.

**Computer Literacy:** High

**Number of KwikSort maps:** 6

**Previous Mapping experience:** As a writer and designer, User A often has to explore associations between ideas. For instance, User A might draw maps to explore how other people will relate to the content of a presentation, to the appearance of a brochure, or to possible associations connected with a proposed name for a new product. However, despite needing to explore associations between ideas, User A rarely maps these associations on paper. The best way to describe User A's way of working (colloquially) is to say that he maps in his mind's eye. On the occasions User A does externalise his thinking in a map-like format, he tends to use maps to provide a framework for his thought processes. As soon as he has identified key ideas and some form of structure between those ideas, he goes back to using his mind's eye because he feels it is faster. Overall, User A reported that he is generally loath to externalise his ideas because he feels that externalising ideas takes too much time and interferes with his flow of thought, which in turn he feels interferes with his ability to think creatively.

**Comments:** Given his background in computing, User A was interested to use KwikSort, but was sceptical about using a computer to map with. His comments reflect an ambivalence to the whole concept of computer-assisted mapping. Firstly, User A liked the way in which KwikSort enabled him to move ideas around a work space, but he was

irritated by the amount of time it took to type ideas into that work space. He said that, for him, the process of typing interfered too much with his thought processes. Secondly, User A liked the presentational quality of KwikSort, because ideas can be sorted using different colours and fonts (etc.). However, on the other hand, User A felt that a high presentational quality might dissuade people from scrapping bad ideas. Having drawn 'nice' looking maps, people may be loath to make changes to them. Overall, User A felt that if he needed to draw a map for someone else, or for his own reference, then KwikSort would be a useful tool. Otherwise, User A felt that KwikSort would be more of a hindrance than a help. As a 'post script', User A commented that he disliked the speed of PLUS (even though he was using it on a 33 MHz 486) and the way in which PLUS failed to keep the conventions which newer Windows products were establishing.

### **6.2.2 User B**

**Background:** Lecturer for the Business School at Kingston University.

**Computer Literacy:** Very High

**Number Of KwikSort Maps:** 2

**Previous mapping experience:** User B learned how to map from a book written by Tony Buzan, three years before using KwikSort. He sometimes uses maps to develop outlines for lectures and projects, and sometimes uses maps as course handouts to orient students into new subject domains. When planning lectures and projects, User B often uses mapping as a supplement to a program called PC Outline. He feels that mapping helps him when he needs to concentrate on relationships between ideas, whilst PC Outline helps him when he needs to quickly order ideas into an appropriate sequence. User B admits that he often chooses to use an outliner rather than a map, not because the outliner gives better results, but because the outliner is faster. He finds that having brainstormed his ideas into a word processor, it slows him down to start drawing a paper-based map, whereas the outliner provides him with all the flexibility he needs in order to reorder his ideas

sequentially. Recently, User B has become interested in the potential of hypertext, as an environment for representing information in an associative way. This interest in hypertext has caused him to look at mapping in a new light. Part of User B's renewed interest in mapping is based on the way he 'likes to think'. Usually he likes to think in terms of 'images and associations'. In the future, he would like to see hypertext become more accepted as a medium of expression in the academic world - perhaps asking students to submit hypertext documents rather than written work, as part of their assessment.

**Comments:** After using KwikSort for a while, User B had both positive and negative comments to make about the program. On the positive side, User B felt that KwikSort made drawing presentable maps far easier than the graphics applications he had been using previously. While using CorelDraw 2.0, he found that the layout and menu system interfered with his train of thought. In contrast, he liked the way in which KwikSort provided him with a way to think associatively, whilst at the same time producing a hypertext record of his thought processes. This was a boon for him, because it enabled him to achieve two separate goals using a single process. He no longer had to map on paper and then go through a time consuming process of transferring the map into an electronic format. On the negative side, User B felt that KwikSort had some problems which needed to be ironed out. At the moment, whilst liking the design, User B felt that there were a number of problems with the implementation of KwikSort. The implementation problems mostly related to the PLUS environment. User B felt that the PLUS environment seemed cumbersome and that it was a pity that it was not possible to have vector-based links between ideas. In terms of output, User B felt that there was a need to be able to convert KwikSort maps into WMF format and to be able to print at a high definition. He was unimpressed with the low-grade bit-map output which PLUS provides as standard.

**General:** In terms of a 'wish list', User B would like to see KwikSort linked up to a digitised tablet and combined with OCR software, so that hand-written maps could be

scanned in and converted into clean computer-based maps. This idea excited him, as it would allow him to work in rough on paper, then convert these rough maps into a computer-based image.

### **6.2.3 User C**

**Background:** Educator for the charity Tear Fund

**Computer Literacy:** Low

**Number of KwikSort Maps:** 4

**Previous mapping experience:** User C had not mapped before using KwikSort, and was unable to make any comparison between paper-based mapping and computer-based mapping.

**Comments:** As someone new to computing, User C found the graphical interface intuitive and easy to master. User C appreciated the way in which KwikSort enabled him to get an overview of the lessons he was planning. He appreciated the way in which KwikSort enabled him to try different lesson plans out, with a minimum of effort. At the time of the interview, User C was hoping to use KwikSort maps to aid lesson preparation and to supplement his handouts. To this end, he suggested that a virtual A4 work space would be useful to him, since most of his handouts are A4 in size.

## 6.2.4 User D

**Background:** Social worker

**Computer Literacy:** Low

**Number of KwikSort Maps:** 2

**Previous mapping experience:** User D learned about concept mapping on a course he took about three years before using KwikSort. Since that time User D has used mapping when taking notes in lectures and as an aid whenever planning anything, such as a report or a presentation. What User D wants from concept maps is an holistic overview of the subject domain, which he can then look at and use to discern a logical way in which to describe the domain verbally to others. Though User D sometimes keeps his maps to remind him of the thought processes involved in preparing a talk or presentation, he does not value maps as an end in their own right.

**Comments:** With respect to mapping, using KwikSort, User D said that there were only two situations in which drawing maps in a computer would interest him: first, when his maps are going to be shown to others, because a computer is able to help him generate better looking maps more easily than would be possible by hand alone; secondly, when he needed to store maps, in order to look at them at a later date. Currently, neither of these situations figure much in User D's mapping goals. He therefore felt that he would be unlikely to use a computer as a mapping medium, but would rather continue with his use of paper-based media.

## 6.2.5 User E

**Background:** Finance director

**Computer Literacy:** High

**Number of KwikSort maps:** 4

**Previous mapping experience:** User E learned to map about 9 years before using KwikSort. He says that, in his experience, there are 'those who take to mapping, and those who don't'. User E says that he is someone who definitely 'does' - he uses mapping a lot. He uses it to prepare for meetings and to take notes during meetings. He believes that by making notes in map format, he prevents himself from being committed to a fixed opinion before he has all the information on which a decision should be made. For User E, maps act like mental scaffolding, allowing him to explore a problem and to decide what a solution should look like before committing himself to the 'detail' of that decision. Since User E views maps as 'scaffolding', he often dispenses with them once they have served their purpose. Only occasionally does he keep maps for future reference.

**Comments:** User E feels that KwikSort's main strength is that the system allows ideas to be quickly dumped and sorted, whereas other computer packages require some element of 'pre-sorting'. He feels that KwikSort allows him to 'brain-dump' his ideas onto a note pad, which then frees him to develop those ideas further. User E says that he likes the way that KwikSort encourages a more holistic approach to problems, and helps people to respond to those problems with more insight than might otherwise be possible. On the minus side, User E feels that KwikSort's main limitations are the lack of dynamic vector-based links between ideas and the lack of a virtual work space. He would like to be able to move links faster than is possible using bit-mapped tools. As a third criticism, he also criticises the poor standard of printout which PLUS generates. With regard to the future development of KwikSort, User E thought that it would be interesting to see KwikSort used in group situations, but felt that there would have to be significant changes in the technology, if

KwikSort were to be accepted by management culture. He said that managers do not generally like typing or using a mouse, so there would probably need to be some kind of pen input or touch-screen control.

### **6.2.6 User F**

**Background:** PGCE student

**Number of KwikSort maps:** 6+

**Computer literacy:** Low

**Previous Mapping Experience:** User F's approach to mapping was originally influenced by Tony Buzan. User F used mapping to take notes and to revise, when he was studying for his GCE O Levels. However, despite the fact that he found mapping a useful and effective study aid, he said that he did not use mapping very often, because of the effort involved. User F used to find mapping frustrating, because of the number of times a map would need to be re-drawn as new ideas and links were added to the map. He found that it was difficult to anticipate how ideas might relate together, and so his maps would often become cluttered and need re-drawing.

**Comments:** What User F most liked about KwikSort was the way that ideas could be moved around the work space and expanded. The facilities enabled User F to keep his maps neat, and did not restrict the number of ideas which he could brainstorm, thus alleviating the problems which had caused him to find paper-based mapping such an unrewarding experience. User F expressed a particular liking for the expand function, because it encouraged him to do more brainstorming than he might otherwise have done. He liked the way that he was able to explore new associations and ideas, without feeling that 'he might run out of room'. In terms of negative comments, User F's main negative comment regarding the use of computer-based mapping related to his lack of computer literacy. He said that it took him a while to get used to interacting with a mouse and

keyboard. In terms of other negative comments, User F felt that he got a 'bit bogged down', when drawing lines between ideas. He did not like the way that KwikSort required the mapper to erase and re-draw lines when ideas were moved, and would have preferred vectored lines which can be selected and moved without the need to erase. In addition, User F said that he would have liked to be able to use a virtual work space, so that his map could be expanded to fill an A4 sheet of paper. However, if a virtual space were provided, he would not wish for navigation to be by scroll bar, which he found awkward to use, but would prefer some other method.

**General:** User F thought that although it takes it takes him longer to type ideas into a computer than to write them on paper, this need not be a problem. He felt that the speed at which he types is fast enough to allow him to think creatively in KwikSort, but slow enough to dissuade him from getting too side-tracked.

### **6.2.7 User G**

**Background:** Management consultant

**Computer literacy:** Very High

**Number of KwikSort maps:** 3

**Mapping experience:** User G learned to use maps as an aid to problem solving, from the managing director of a company for which he used to work. His company used mapping to facilitate marketing and product development. User G provided two examples of the ways in which mapping had benefited the company. In the first example, mapping was used to help find a way to market a line of torque screwdrivers. Marketing the screwdrivers had proved a problem, because the market for torque screwdrivers was relatively small. Using brainstorming and concept maps, the company decided that one way to increase sales would be to embark on a long-term education policy. The company



encouraged seminars on torque screwdrivers at universities. This resulted in academic papers on the advantages of torque screwdrivers, which in turn generated articles in the more popular press. Articles in the popular press made people more aware of the advantages of torque screwdrivers, which in turn led to an increased market and increased sales. In the second example, User G's company had become aware that their product was not selling, because the target market was not responding to the brand name. By brainstorming the associations connected with the current brand name, they realised that the name was putting them at a competitive disadvantage, because the name had the wrong connotations. They realised that the engineers to whom they were selling liked to buy tools with strong names (such as 'heavy duty'), or which were known by an acronym (for instance TLS 323). By continuing to brainstorm and concept sort, the company were able to come up with a better name, which more accurately reflected the image they wished to communicate. Currently, User G mainly uses mapping to augment talks and presentations. User G uses maps as the framework around which to construct the linear form of presentations.

**Comments:** User G had both positive and negative comments to make about KwikSort's utility. On the positive side, User G felt that KwikSort gave him more control over the development of his maps. The dynamic work space enabled him to make changes and explore options, without having to re-write the map. This was important to User G because he likes to work in a tidy work space, and finds that keeping the work space tidy using traditional mapping media can be difficult. User G was also pleased because with more freedom to make changes to his map, he found that KwikSort encouraged him to make more associations than he would normally make using pencil and paper. The software enabled him to expand each idea onto a map of its own, and allowed him to navigate easily between maps - so although screen size was constricted, the work space allowed him far more flexibility than the whiteboards on which he normally works. Indeed, User G felt that having a small screen might even be a bonus, because the mapper is forced to be concise, and is encouraged to prune ideas during the sorting process. On the

negative side, User G felt that KwikSort had several interface problems, which he would like to see addressed in future versions. Most of these problems were connected to the use of PLUS as the implementation language. Firstly, he did not like the way that PLUS often seizes control of KwikSort, flashing up the PLUS logo (for instance when printing). Secondly, he did not like some of the Macintosh-based icons which PLUS provides, for instance the Macintosh watch, instead of the Windows hour glass. As an experienced Windows user, User G felt that Macintosh aesthetics jar, when viewed in a Windows environment. He would prefer the implementation language to remain hidden in the background.

**General:** In terms of a 'wish list', User G had two main wishes. Firstly, he felt that it was essential for there to be a spell checker, if KwikSort were to be used as a fully functional presentational tool. He explained that it would take him too long to check spelling manually and there is the possibility of making an embarrassing mistake. Secondly, he would like the ability for brainstorm and map files to be held separately. He referred to the way in which integrated packages such as Microsoft Works allow a user to overlay and move information between windows. He felt that using this format would allow brainstorming and mapping to be held in separate files, which would facilitate the movement of ideas between files, which at present is difficult to achieve.

## 6.2.8 User H

**Background:** Final year Ph.D. student in the Human Computer Research Laboratory at the Open University, studying Neural Networks.

**Computer Literacy:** High

**Number of KwikSort Maps:** 3

**Mapping experience:** User H learned about concept mapping in a workshop which he attended when studying for an MSc in Artificial Intelligence. However, User H rarely uses mapping, because it does not fit well with his preferred way of thinking, which he describes as ‘highly associative’. User H finds that he generally gets good results by letting his mind ‘run free’. He finds that, by working in this way, essays and projects seem to find their own structure and form. He only maps on paper, when there are too many ideas for him to hold in working memory, or when he wants to make sure that he does not forget something.

**Comments:** User H used KwikSort to organise ideas for a project, in which he needed to collate a number of different records. User H said that KwikSort helped him in this task, because the structure of the program allowed him to quickly externalise the hierarchies which he had generated in his mind's eye. He felt that KwikSort helped him in this situation because there had been too much information for him to hold in working memory all at once. Having got his ideas together, User H felt that maps would be a good way to communicate those ideas; however, he also felt that he would only use maps where others expected it of him, and he would not initiate their use as a medium of communication. With regard to criticising KwikSort, User H said that he would like to see: better paint tools, a virtual work area, and dynamic vector-based links between boxes. He would also like ideas boxes to fit to text automatically, after being edited.

## 6.2.9 User I

**Background:** Lecturer in the Business School at Kingston University.

**Computer Literacy:** Medium

**Number Of KwikSort maps:** 3

**Mapping experience:** In his official capacity at Kingston University, and as an active political campaigner, User I's work involves the persuasive communication of ideas. User I hopes that what he says will have a positive impact on the lives of others - which means that he needs to tailor each message to the audience to whom that message is addressed. In preparing notes for a talk or a book, User I will often employ a mixture of brainstorming and informal mapping by sketching ideas out quickly on a sheet of paper. He finds that such informal mapping helps him to select the 'language' and the 'content' of a presentation. However, User I adds the rider that more often than using paper, he likes to explore associations between ideas in his mind's eye. He finds the process of making linguistic associations is a natural one. He only uses an external aid (such as mapping) when the subject domain is too large for him to hold everything in his mind at the same time, or when he wants to note associations down so that he can forget about them and get on with something else. When asked whether he ever showed his maps to others, User I replied that he feels that the main use of concept mapping is to provide the framework in which further work can take place. For instance, after completing a talk, the maps used to prepare that talk should be dismantled - so as not to constrain future thought.

**Comments:** In order to evaluate KwikSort, User I used the application to generate ideas relating to possible uses for an abandoned factory. In particular he was interested in modelling people's attitudes to the physical site and their possible reactions to the wording of the different development proposals which might be put forward in the near future. Whilst mapping people's attitudes, User I felt that the most important facilities which

KwikSort provided were the dynamic ideas boxes. He felt that the other tools were like the icing on a cake. They helped make maps look better, but they did not contribute to the real job of the map, which was to help him focus on associations between ideas. With regard to improvements, User I felt that KwikSort needed to be more smoothly integrated into the Windows environment, so that data could be easily imported and exported. Once this had happened, User I would like to see KwikSort used to help produce maps for inclusion in course handouts and as a way to facilitate group work amongst some of his senior students.

### **6.2.10 User J**

**Background:** Post graduate student at IET, Open University

**Computer Literacy:** High

**Number of KwikSort maps:** 6+

**Previous mapping experience:** User J has known about mapping since the mid 1960's, but rarely uses it. He says that he has a highly associative mind, and that mapping encourages him to produce more association, rather than helping him focus his mind on the goal to which he is supposed to be working. Thus, User J prefers to use goal setting techniques when he is planning or problem solving, because goal-setting helps him to focus on 'the task in hand'. The only time that User J would feel that mapping is useful, is when there is an ill-defined problem, or when there are too many ideas for him to hold in his head at any one time. For instance, twice in recent years, User J has used mapping to help him make important personal decisions.

**Comments:** User J's main comment was that he found the time taken to type ideas into the computer irritating. Consequently, he mainly used KwikSort as a 'graphical database', into which he could 'brain-dump' information about his Ph.D. User J felt that a computer was the wrong environment in which to map. He reported experiencing computer-based

mapping as ‘too formal’, because typing and looking at type-written script gives a map maker a very different impression to using a pencil and looking at a sketch map. The sketch map is much more ‘tentative’, whereas the computer-generated map looks much more ‘final’.

### **6.2.11 User K**

**Background:** Course co-ordinator / educator

**Computer Literacy:** Low

**Number of KwikSort maps:** 6

**Previous mapping experience:** User K was never formally taught mapping, but ‘picked it up’ from his ‘A’ level history teacher and ‘developed it from there’. At college he used maps to plan essays and to help with his revision. After college he began to use mapping to plan meetings and talks. User K says that he has now reached the point where it is unusual for him not to use maps when planning something. For him, maps have become the mental scaffolding which enable him to integrate ideas into a coherent whole. User K feels that his main strength is thinking analytically and logically. He feels that he needs maps if he is to be able to plan effectively, because otherwise he tends to find it difficult to visualise possible associations and links between ideas which he is discussing. This causes his work to suffer, as he misses avenues of thought which might have been useful to pursue.

**Comments:** User K liked using KwikSort, and he gave the following positive criticisms. User K found that the KwikSort interface helped him to work in the way that he likes to work:- to brainstorm a few key ideas, to explore relationships between ideas, to expand on those ideas, then to brainstorm further. He found that he liked the way in which an electronic environment allowed him to re-write ideas without having to re-write the whole map, and allowed him to cut and paste ideas between maps, enabling him to build a library

of resource maps which he could re-edit according to the needs of the students he was teaching. User K's only negative comments were that it would have been useful to have dynamic (vector-based) links between ideas boxes, and that the PLUS environment sometimes crashed inexplicably on the computer on which he was working.

### **6.2.12 User L**

**Background:** Computer analyst.

**Computer Literacy:** High.

**Number of KwikSort maps:** 3

**Previous mapping experience:** User L learned to use concept maps at school, and has made regular use of them ever since. User L uses maps to collect ideas before planning things such as projects and reports. She finds that maps are a much better way in which to structure thinking than any other that she has tried. She likes the way in which maps enable her to represent her thinking, so that she can become aware of possible 'blind spots'. User L is highly analytical, having acquired a degree in chemistry from Cambridge, but she does not find it easy to visualise connections in her head. Therefore, by representing associations in a map-like format, she does not have to worry about forgetting anything, or about failing to recognise an important relationship. When User L does not use maps, she finds that ideas come to her as she begins to write, but that she then has to re-structure her writing to fit the new ideas in - which wastes both time and effort.

**Comments:** The features which User L most liked about KwikSort were the ability to move ideas around the work space and the ability to expand ideas onto new maps of their own. User L felt that the ability to expand ideas was especially important, because it meant that whilst she was concentrating on making associations, a hierarchy was automatically being formed within those associations. As someone who has programmed

graphics packages, the facilities which User L would most like to see added to KwikSort were dynamic vector-based links between ideas and a tool which allows the user to group ideas together and move them *en bloc*.

### 6.2.13 User M

**Background:** Computer consultant / electronic publishing consultant

**Computer Literacy:** High

**Number of KwikSort Maps:** ~ 6

**Previous mapping experience:** User M started using paper-based mapping after seeing a demonstration of the computer program C.K.Modeller. He was impressed by how 'obvious' the benefits of mapping were, and felt it was strange that mapping was not in wider use. For User M, mapping seemed to be a natural extension of traditional brainstorming. The maps which User M likes to draw tend to consist of pieces of paper stuck onto a large pin board or A3-sized pieces of paper. The maps tend to be highly informal and only consist of 30 or so ideas at any one time. What User M values most about mapping is that it enables him to develop an 'intuitive game plan', by encouraging him to express associations between ideas. User M says that he is constantly amazed by the way in which mapping makes the 'obvious' *obvious*. He often wonders why the obvious so often gets missed. The following is an example of how something obvious, yet unrecognised, affected User M's work. User M's work is electronic publishing. He had permission to publish several sets of data and decided that he needed to map out a business strategy. When he mapped his business strategy, he found that each of his publications would need an advertising flyer. He also found that 70% of the text in each flyer was the same. Having recognised this, it became evident to User M that if he were to create a template for his flyers, he would save himself a lot of work and at the same time create a strong house style. User M says that, when he thinks about it, the idea of a



template was obvious, but for some reason it had eluded him in his previous work, causing him to waste both time and money.

**Comments:** KwikSort did not prove to be a highly successful environment for User M to map in. He felt that he really liked the idea of mapping in a computer, but that in practice mapping in a computer did not suit him. The main problems that he found were that typing ideas into a computer took longer than writing them on paper and that he disliked being forced to work in a screen-sized work space. User M emphasised that the main block for him was the size of the work space. He said that the size of a 14' monitor was a problem which 'haunted' many aspects of his work with computers. He feels that computer screens are problematic because they derive from T.V. technology, whereas his work (Desk Top Publishing) derives from the culture of printing. Again and again he finds that the two cultures do not interact well, and that many of his computer tools do not contribute to the process of printing as well as they might.

**General:** Strangely, what User M liked most about being presented with a program like KwikSort, or C.K.Modeller, was that it encouraged him to use mapping on paper, and gave him new insights into ways in which to apply the principles of mapping to some of the practical problems which he faces. Thus, he found the program more useful in an educational role than in a tool-based role.

#### **6.4.14 User N**

**Background:** Lecturer in English at Kingston College

**Computer literacy:** High

**Number Of KwikSort Maps:** 3

**Previous mapping experience:** User N learned to use concept maps from an English textbook about 5 years before using KwikSort. He makes extensive use of maps to help his students develop ideas for essays and assignments, and to help students uncover the hidden meaning in the English texts which they are studying. User N tends to map onto a whiteboard. Usually, the map on the board is used as the focus for a class discussion. He finds that mapping helps students to build upon each others' ideas, and helps the group to externalise their thinking - which he finds helps students to think more creatively and allows him to get some insight into how well the class understand what they are studying.

**Comments:** With regard to KwikSort, User N had three comments, two positive and one negative. On the positive side, User N felt that the layout of the tools was intuitive, because he had soon felt at home using KwikSort. Secondly, the dynamic environment made it easy for him to brainstorm and sort his ideas, without having to re-write those ideas, as he would have to on paper or on a white board. On the negative side, User N felt that the main problem facing KwikSort was one of technophobia. He felt that whatever the merits of the program, there would be many people who would not use it because there are many in his department who do not like using computers.

**General:** With respect to the future, User N felt that he would like to keep using KwikSort. In particular he was keen to get groups of students drawing maps in the computer labs, as a preparation for classroom discussion. User N did not think that he would use KwikSort to prepare class notes, as he felt that this would prevent his students

from being creative in the way in which they explored ideas and associations in the classroom.

### **6.2.15 User O**

**Background:** Lecturer in IT at Kingston College Of F.E.

**Computer Literacy:** Very High

**Number of KwikSort Maps:** 3

**Previous mapping experience:** User O feels that his intellectual strength is in attention to detail and in the sequential analysis of that detail. User O learned to map as part of his teacher training. He used mapping for revision and essay writing. User O finds that mapping helps him by providing a sense of overview and context, which he says that he loses because of his attention to detail. Although User O values what mapping can give him, he rarely uses it. The reason for the lack of use is that User O finds it difficult to draw neat maps. The poor quality of hand-drawn maps causes User O to find mapping frustrating. The aesthetics of the map would tend to distract User O from exploring the associations between different ideas.

**Comments:** One of the main advantages which User O found when he used KwikSort, was that he could let the computer take care of the presentational aspects of mapping. If he made a mistake, or wanted to rearrange his ideas, the computer allowed him to do so. User O feels that the computer has made mapping a 'fun' process, which has encouraged him to use mapping far more than he did previously. User O now hopes to use KwikSort to help him prepare new lectures and course material. However, he feels that KwikSort could be improved by adding dynamic links between ideas boxes and by making it easier for users to work in a virtual work space. He would also find it useful if KwikSort could run on lower-spec computers, since there are few 25 MHz machines available in his department.

## 6.2.16 User P

**Background:** English teacher in a large comprehensive school

**Computer Literacy:** Low

**Number of KwikSort Maps:** 4

**Previous mapping experience:** User P often uses concept sorting and concept mapping in classroom situations, in order to help students to think more creatively and to better comprehend what they are reading. Normally, these maps are drawn as a result of class discussion. Currently, User P rarely uses mapping as a way to prepare for lessons, because he has had several years' teaching experience, and so he has already produced most of the lesson plans he needs. User P feels that maps are most useful when students have to construct them, rather than when they are given someone else's map to read (as a handout).

**Comments:** User P used KwikSort to prepare some tutorials. He said he found that KwikSort was easy to 'pick up' and that it helped him to generate fresh ideas. He especially liked the ability to move ideas around the map surface, allowing new combinations of ideas to be tried out. User P contrasted the dynamic work space in the computer with the use of a whiteboard, where it is relatively difficult to move ideas around. User P had no specific criticisms of KwikSort, but felt that this may have been because he has had little experience using a graphical interface. With regard to future use of KwikSort, User P said that he would find such a program useful, if hardware were available which allowed him to conduct group mapping sessions in the classroom.

## 6.2.17 User Q

**Background:** Lecturer in IT at Kingston College Of F.E.

**Computer Literacy:** Very High

**Number of KwikSort Maps:** 8

**Previous mapping experience:** User Q learned about concept mapping whilst studying psychology at university. Whilst at university he used the technique as a revision aid. He would make key-word maps, and then 'expand' those key-word maps using note cards. Since leaving university, User Q has used mapping in order to plan lessons and structure personal projects. When doing this, he tends to draw very rough maps, which are then scrapped and re-drawn more neatly. Often, since the re-drawing process takes time, maps are only used as rough work and then thrown away. Currently, User Q is interested in hypertext-based maps as a way of preparing lessons, whilst at the same time allowing him to construct 'electronic course notes' which students can use as revision aids. User Q is also interested in the possible use of hypertext-based projects as the focus for group work.

**Comments:** With regard to KwikSort's utility, User Q expressed the opinion that there were three key ways in which KwikSort helped him attain his mapping goals. Firstly, KwikSort provided him with an intuitive interface, allowing him to quickly begin to draw the kinds of maps he wanted. Secondly, the provision of dynamic ideas boxes, dynamic links, a note pad, and an expand facility made mapping in a computer much easier than mapping with a pencil and paper. Thirdly, KwikSort allowed him to experiment with the possibility of creating hypertext-based electronic notes to distribute to students. He said that KwikSort excited him because with no effort on his part a hypertext document grows naturally as his thinking develops. However, there were four improvements which User Q felt would be needed to fully realise KwikSort's potential. He said that, firstly, he would like more tools to make it easier to define box styles. In particular, there should be more fonts available than those currently provided on the defaults menu. Secondly, it would be

helpful if there were an option which allowed multiple lines of text to be auto-written to a single ideas box. Thirdly, it would be easier to draw maps using vector-based, rather than bit-mapped based tools. Fourthly, there needs to be better integration between KwikSort and other word processors and graphics packages.

### **6.2.18 User R**

**Background:** Lecturer in the Institute of Educational Technology, part of The Open University.

**Computer Literacy:** High.

**Number of KwikSort Maps:** 20

**Previous mapping experience:** User R learned about concept mapping some ten years before using KwikSort, when he was part of a team of six people designing a new college course. The group spent two days brainstorming and concept sorting. Ideas were written onto cards and then fixed to wall-boards using magnets. User R found that the resulting maps enhanced brainstorming by encouraging the cyclical generation of new ideas. He also found that maps improved communication between group members by enabling each member to explore the associations they held towards the key concepts under discussion. Such an exploration helped to flag up areas of commonality and/or difference - which in turn helped to flag up potential areas for misunderstanding, where one or more people had made assumptions about an idea which were not shared by the group as a whole. Since this very positive experience, User R has made much use of concept mapping on a personal basis, but little use of it in group sessions. He finds that people are often resistant to the idea of using mapping, because it has not been generally encouraged in the corporate cultures of which he has been a part. User R feels that the resistance to the use of concept mapping is counter-productive to corporate efficiency, since most organisations make much use of groups to make decisions, and brainstorming followed by

concept sorting would help people to clarify what it is they are discussing - which would help them find solutions and reach decisions far faster.

**Comments:** User R reported that KwikSort enhanced his work in four ways. Firstly, the computer allowed User R to move ideas around the work space and generate new ideas whenever he wished. He finds this useful, because it means that he can use KwikSort to focus some of the planning and tutorial meetings which are a part of his work. KwikSort provides him with an electronic whiteboard, onto which ideas can be posted and new ideas generated. Having generated and sorted a number of ideas, the second way in which KwikSort aids User R is by allowing him and the others at a meeting to keep a map-based resume of the decisions taken within the meeting. Thirdly, since meetings for different projects may be several weeks apart, User R found the expand facility useful, as it allowed related maps to be linked electronically, thus allowing earlier maps to be reviewed relatively quickly. This review feature was useful, and helped User R get back into the same frame of mind that he was in at the close of the previous meeting. However, in addition to the positive comments, User R also had a number of criticisms to make. The main criticism was that he felt that KwikSort had too many facilities - that options to help improve presentation tend to divert attention away from the main purpose of the application, which was to help people to explore ideas.

**General:** User R's wish list was concerned with hardware. At the moment, User R uses KwikSort to help focus small meetings between two or three people. What User R would like to be able to do is to use KwikSort in combination with an OHP screen, so that he could use KwikSort in larger gatherings.

## 6.2.19 User S

**Background:** Year 1 undergraduate studying Social Anthropology / ex social worker.

**Computer Literacy:** Medium

**Number of KwikSort Maps:** 6

**Previous mapping experience:** User S learned to use concept maps in a study class, about a year before using KwikSort. As a social worker, User S had been using 'map-like' representations in the form of genograms (which are map-like representations of family interactions). User S now uses maps to achieve a number of diverse mapping goals - for instance: planning essays, planning projects, as a revision aid, and as a way to organise thinking. User S likes concept mapping because he tends to think 'visually' and 'associatively', and thus maps help User S to express his ideas in a way which he finds intuitive. User S feels that mapping helps him to think more holistically, providing him with an overview prior to forming a linear argument. He says that without a map-based overview he tends to miss ideas out, which causes the standard of his work to drop.

**Comments:** There were many aspects to mapping in a computer which User S found attractive. He especially liked the dynamic nature of the environment, which enabled him to work more neatly because he did not have to cross ideas out or rewrite them. Within such a dedicated environment, User S found that he used mapping more and was more willing to explore the potential of mapping. User S also liked the way in which the expand facility encouraged him to explore new associations, because he could drop down a level onto a new map without having to worry about cluttering up his top-level maps. Finally, User S liked the way in which information stored on a map could be copied and used to generate new maps, or exported and used in other applications, such as graphics packages or word processors. User S's main reservations were to do with the limitations imposed by PLUS. He would have preferred to have dynamic vector-based links between ideas, cleaner output than the low grade bit map offered by PLUS, and a spell checker.



**General:** In the future, User S would be interested to try KwikSort in a group setting and to use the program to facilitate discussion - though he realised that before he could do this, he would need to get access to a large screen.

### **6.2.20 User T**

**Background:** Post-graduate student at IET, Open University

**Computer Literacy:** Medium

**Number of KwikSort Maps:** 5

**Previous mapping experience:** User T uses paper-based concept mapping for planning essays and projects and for revision work. He likes to externalise his ideas using pencil and paper after ordering them in his 'mind's eye', because he finds that by externalising his thoughts in a map-like format he ensures that he does not forget them. He finds that maps help him express his thinking in ways which a sequential text format do not allow. Thus, it would be unusual for him not to use maps in his work.

**Comments:** User T's feelings about KwikSort were not particularly positive, in terms of KwikSort's utility. He reported that personally, he would prefer to use pencil and paper when drawing a rough map, because he can work much faster on paper, and get all his ideas onto one sheet of A4 paper where they can be easily scanned. The only time in which User T would feel that KwikSort would be useful, would be when he needed to draw a map which was to be presented to others. In terms of a wish list, if User T were to use KwikSort, he would want to see the addition of a 'bring to front' / 'send to back' facility.

## 6.2.21 User U

**Background:** Church leader

**Computer Literacy:** Low

**Number of KwikSort Maps:** 10+

**Previous mapping experience:** User U has used concept mapping for over 10 years. He first learned about mapping as an undergraduate studying psychology. Since then, User U has used mapping to help him whenever planning projects or talks.

**Comments:** Normally, User U only draws rough maps, which he throws away. He found that the biggest advantage of using KwikSort, has been the improvement in the presentational quality of his maps. Sometimes, he now uses his maps as handouts when he is speaking / teaching. He feels that a graphical representation of his talks encourages people to actually look at his notes, because they are more aesthetically pleasing and easier to understand. In addition, User U feels that the improved presentational quality encourages him to draw more maps, because the end product makes mapping more fun than it was when he was mapping with a pencil and paper. He had, in the few months prior to using KwikSort, been using mapping less and less frequently, because of the effort involved in keeping maps neat. User U's main criticism of KwikSort was that KwikSort ran slow and interrupted his thinking. On discussing the issue, it seemed that the problem was mainly due to the slow speed of PLUS, and the fact that KwikSort was being run on a 12 MHz 286. With regard to extra features, User U felt that he would like to have a 'random spread' option for ideas. After brainstorming, User U likes to spread all his ideas out before sorting them, and was not quite happy with the current spread facility, which spreads all the ideas down the right-hand side of the screen.

**General:** As regards future use, User U felt that he would carry on using KwikSort in the way that he was at present. When asked, he also agreed that he might find it useful to use KwikSort in a meeting situation, as a way to externalise the discussion, though he realised that he would need a faster computer and a larger screen if this idea were to be properly implemented.

## 6.3 Collating the notes

The notes collected in interviews with KwikSort users are summarised below in tabular form, to highlight some of the patterns which emerged when asking KwikSort users about their perceptions of concept mapping in general, and their perceptions of computer-based mapping in particular. The tables cross-reference the comments made by users with the way in which each user chose to work. On the left of each table is a column which shows the comments made by the seventeen people who reported mapping organically. In the middle of each table is a column which shows the comments made by the four people who reported engaging in disclosure mapping. On the right of each table is a column summarising the comments made by mappers.

### 6.3.1 How people react to mapping in a computer-based environment

**Fig 6.1** presents users' reactions to mapping in a computer-based environment. The table illustrates how different people experience the same environment in different ways. It suggests that about 70% of people in the study are attracted to computer-based mapping, because they want to map organically and a computer provides them with a dynamic environment in which to generate and sort ideas; 10% of people in the study do not want to use a computer, despite mapping organically; the other 20% of users in the study engage in disclosure mapping and dislike computer-based mapping using KwikSort. The table shows that the main reason given for not wanting to use a computer-based mapping application was the need to use a mouse / keyboard input. Having already decided how ideas relate to one another, people felt that typing ideas into a computer took longer than sketching those same ideas on paper and therefore tended to interfere with their flow of thought, as they endeavoured to externalise their mental model of the domain being mapped. Thus, unless a way can be found to speed the input of ideas into a computer, relative to the speed of sketching ideas on paper, it is unlikely other people engaged in disclosure mapping will find computer-based mapping an attractive option. By contrast,

people engaged in organic mapping liked using a computer-based mapping application because it gave them a dynamic environment in which to generate and sort their ideas, without the constraints of static media which make it difficult for the mapper to move ideas around the work surface.

### 6.3.2 Users' perceptions of KwikSort facilities

Fig 6.2 presents the users' attitudes towards different KwikSort facilities. As may be seen, most users who map organically agreed on the features which they found most useful. People mapping organically liked the way in which they could brainstorm ideas onto a note pad, autowrite ideas to and from the ideas boxes, move ideas around, and expand ideas onto new maps. Users especially liked the expand facility, which seemed to inspire people to keep exploring for new associations - allowing new ideas to be generated without the work surface becoming cluttered

### 6.3.3 Features which need to be added to KwikSort

Table Fig 6.3 presents the views of users relating to additional features which they would like to see added to KwikSort. Most mappers utilising an organic protocol felt that KwikSort could be improved through the addition of **dynamic links**, a **virtual A4 work area** and through the **re-implementation of KwikSort in a language other than PLUS**. People mapping organically felt that vector-based dynamic links (between ideas boxes) would reduce their work load, because there would be less need to re-draw links every time an ideas box was moved; that a virtual A4 work area was useful, because most of the users print onto A4 paper; and that, for those working under Windows, PLUS's Mac-like aesthetics and conventions were irritating. Interestingly, three of the four people utilising a disclosure protocol said that they would be interested in a computer-based mapping application which could be used as a visual database, in which comprehensive reading / lecture notes might be graphically stored, related and cross-indexed.

### 6.3.4 Changes in people's attitudes to mapping after using KwikSort

Fig 6.4 shows how use of KwikSort appears to have changed users attitudes towards mapping. Whether as a result of using KwikSort, or as a result of taking part in a mapping project, several mappers began to want to make more use of mapping. The main changes in attitude were in relation to:

- group work
- using maps to store ideas
- using maps to communicate ideas.

With respect to group work, six out of twenty-one people (over 25%) felt that they would like to find ways in which to use mapping to support various forms of group work. Nine people (just under 50%) felt that using a computer to store ideas was better than using paper-based maps. With regard to using computer-based maps to store ideas, several disclosure mappers seemed to feel that storing their ideas in a pictorial database would make their ideas more accessible. From conversations with these users, it became apparent that given an important enough project, and given a big enough subject domain, there is a point at which the computer's ability to store and retrieve information provides a motivation for using computer-based mapping which outweighs the effort involved in typing. In terms of communication, whereas before using KwikSort few mappers wanted to keep copies of their maps, after using KwikSort ten people (almost 50%) said that the presentational standard achieved by the computer made them feel that they would like to use mapping as a supplement to written notes and handouts. Mappers now felt that the neat maps produced using a computer were useful records of their thought process, whereas the sketch maps which they had drawn using pencil and paper were too untidy to be deciphered at a later date.

### *An aside*

It is worth noting that several people became very excited about the use of mapping to facilitate their work, when they were shown how to apply mapping to problems they faced. Several users commented that they found that discussing mapping with the author had given them fresh insight into how to make better use of mapping; and one user commented that although he had not used KwikSort very much, having the application on his hard disk had re-focused his mind and encouraged him to make more use of concept sorting. These comments would suggest that an appropriate mapping tutor / expert system, which included a number of case studies and examples, might be a good way to encourage more people to make better use of mapping.

**Fig 6.1: A table correlating comments made by people engaged in organic mapping and in disclosure mapping, with regard to the utility of a computer as a medium in which to draw concept maps**

Organic mapping	Disclosure mapping	Comment
15/17		The user appreciated working in a dynamic medium.
2/17	4/4	The user did not appreciate using a dynamic medium in which to map.
6/17		The user liked the presentational quality of the work space and preferred to use a computer, even if it took longer for them to complete a map.
6/17		The user liked the way in which computer-generated maps were neat enough to give to other people.
2/17	4/4	The user felt that typing took much longer than sketching ideas on paper. Thus, the user would only use computer-based mapping, if they needed to draw a map for someone else to look at, or if they had a lot of ideas and wanted to store them in a map-like database.
2/17		The user felt that they might be able to use KwikSort's hypertext facilities as the basis for asking students to create hypertext documents / maps of subjects which they were studying.
2/17		The user felt that sorting ideas on a VGA screen was not a problem, because small font sizes mean that more ideas can be fitted on a screen than can be fitted on a whiteboard.
1/17		The user felt that although typing took longer than writing, the dynamic work space provided by the computer saved them time while they were sorting ideas.
1/17		The user felt that it would be difficult to persuade managers to use computer-based mapping in meetings, because management culture does not tend to favour the use of keyboards.
1/17		The user said that they often write very small, so that they can get their ideas on to an A4 sheet of paper. They felt that they would prefer to map on one A4 sheet of paper, which is easy to scan, rather than have all their ideas spread out between multiple maps.
1/17		The user felt that they would only want to use computer-based mapping if they had an A4 screen.



**Fig 6.2: A table correlating positive comments made by people engaged in organic mapping and in disclosure mapping, with regard to the design of KwikSort**

Organic mapping	Disclosure mapping	Comment
13/17		The user liked the way ideas and lines can be moved around.
12/17		The user liked the note pad and autowrite facilities.
12/17		The user liked the expand facility
3/17		The user felt that mapping in a dynamic environment encouraged them to explore relationships between ideas more than they did when mapping in a static environment.
1/17		The user liked the way in which KwikSort helped them order their ideas into a 'natural hierarchy'.
1/17		The user contrasted KwikSort with the use of pencil and paper. They said that they felt that pencil and paper forced them to pre-sort their ideas, before they began to draw their maps.
1/17		The user liked the way that they could try out different lesson plans, with the minimum of difficulty.
1/17		The user said that working in a neat environment had caused them to re-evaluate what mapping meant to them. It encouraged them to spend more time on their maps, and to think about what they are mapping more carefully.
1/17		The user liked the way in which KwikSort can be used as a kind of electronic whiteboard. They liked the way in which the hypertext facilities allowed them to link the notes from different meetings, helping them to gain a sense of continuity between meetings with the same people.

**Fig 6.3: A table correlating comments made by people engaged in organic mapping and in disclosure mapping, with regard to ways in which KwikSort could be improved**

Organic mapping	Disclosure mapping	Comment
1/17		The user felt that sorting ideas would be easier, if it were possible to have some way to group and move ideas, rather than having to move ideas boxes individually.
3/17		The user asked if it would be possible to have an A4-sized virtual work space, so that the work space corresponded more closely with the final printout.
1/17		The user felt that the lack of a spell-checker was a major problem for people such as themselves, who wanted to use KwikSort to prepare business presentations.
1/17		The user felt that there was too much functionality in the system, and that they would prefer to see a version of KwikSort, which had less menu items and options.
2/17		The user felt that working on a VGA screen helped to focus the mind and clarify thinking, since they had to delete ideas which were not relevant, to prevent the screen from becoming too cluttered.
2/17		The user felt that vector-based links would be easier to use than bit-mapped links
12/17		The user felt that a virtual work area would improve KwikSort.
3/17		The user felt that there were problems with the PLUS language.
	3/4	The user felt that the development of more sophisticated database support would make KwikSort more useful. The user asked that KwikSort could be used as a graphical database, in which ideas might be stored - for instance, for the storage of reading notes prior to writing a thesis.

**Fig 6.4: A table correlating comments made by people engaged in organic mapping and in disclosure mapping, with regard to ways in which KwikSort has changed the mapper's perception of concept maps as a form of mental scaffolding**

Organic mapping	Disclosure mapping	Comment
1/17	1/4	The user wants to use KwikSort to help teach mapping
6/17		The user would like to use KwikSort to facilitate group work
6/17	3/4	The user wants to store ideas in a map-based database
10/17		The user wants to use maps as a medium of communication

## 6.4 Summary

This chapter presented the findings from the second investigation into users' perceptions of KwikSort. The chapter was split into two main results sections, which are outlined below. Section 6.2 presented a summary of the notes taken during each of the interviews with KwikSort users. Of particular interest was the way in which the notes provide an insight into how different ways of mapping affect the mapper's perception of concept mapping in general and computer-based mapping in particular. Section 6.3 showed that most people map utilising an *organic protocol*, adding and sorting a few ideas at a time, and that people engaged in organic mapping like using a computer-based mapping application, as long as that application provides certain core facilities. Section 6.3 also showed that a minority of people utilise a *disclosure protocol*, that is, the mapper has a set of ideas and relationships in their mind's eye which they want to sketch down quickly. The data indicate that most people engaged in disclosure mapping do not want to use a computer-based mapping application unless there are presentational reasons for doing so. In chapter seven, these findings will be discussed in the context of experimental limitations and the observations made during the literature search reported in chapter two.

Drawing the findings together, the second investigation showed that most people map utilising an organic protocol. They add and sort a few ideas at a time. People engaged in organic mapping like using a computer-based mapping application - as long as that application contains certain facilities. A minority of mappers utilise a disclosure protocol. Mappers utilising a disclosure protocol already know how they wish the map to look. As a result, mappers using a disclosure protocol desire to sketch their ideas as quickly as possible, and find that a computer-based environment interferes with their flow of thought.

# Chapter Seven

## Discussion

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## 7.1 Introduction

The discussion of the results of the KwikSort feedback is divided into seven main sections. In **section 7.2**, there is a presentation of the main findings from the feedback provided by KwikSort users. This leads to **section 7.3**, where there is an evaluation of the experimental limitations and how those might affect the experimental findings. In **section 7.4**, there is a presentation of the new terminology created during the KwikSort study. In **section 7.5**, there is a review of three mapping applications released after the start of the KwikSort study. This review leads to **section 7.6**, in which more terminology is added to that already used to discuss the utility of computer-based mapping applications. In **section 7.7**, all the terminology is collated to produce a checklist with which the reader can define their mapping needs, and assess the utility of any computer-based mapping application relative to those needs. Finally, in **section 7.8**, the development of the computer programs BrainBox and HyperMap is outlined. Both programs seek to demonstrate the process-based tools requested by KwikSort users.

## 7.2 Experimental findings

KwikSort 1.5 was used by twenty-one people, and feedback was elicited through the use of structured interviews. From the feedback, it was found that four-fifths of the users utilised an *organic protocol*. Mappers utilising an organic protocol work in a cyclic way, adding and sorting a few ideas at a time, the maps being used as a form of mental scaffolding which is used to clarify thinking and structure ideas. Feedback also indicated that one-fifth of the mappers utilised a *disclosure protocol*. In a disclosure protocol, maps are used as an *aide-memoir*, rather than as a form of mental scaffolding. Mappers report pre-forming ideas and associations in their mind's eye, then externalising these ideas and associations in a map-like form before they are lost from working memory.

Feedback from the one-fifth of mappers utilising a disclosure protocol indicated that typing ideas at a keyboard affected their ability to concentrate. For example, ideas take longer to type than to sketch using pencil and paper. These people therefore do not find a computer-based mapping application helpful.

By contrast, feedback from the four-fifths of mappers utilising an organic protocol indicated that they do like using a computer-based mapping application. They reported finding six core features of KwikSort useful:

- The provision of a set of 50 text fields, which could be edited in-place or dragged around the work space
- The provision of a set of bit-mapped paint tools, which allowed users to draw links between ideas
- The provision of a note pad which allowed ideas to be easily brainstormed yet kept away from the map surface until the mapper wanted to sort them, and which enabled all the ideas in the current file to be available from any map surface

- The provision of an autowrite facility which enabled text to be freely transferred between the note pad and map-based formats
- The provision of an expand facility which encouraged users to expand a top-level map into a number of lower-level maps
- The provision of the facility to maximise the work space by hiding all the menus or toolboxes.

In terms of improving KwikSort, there were two clear requests: for the facility to prepare maps on an A4 work space, because this was the size of the work space to which most computers print; and for dynamic links based on vector, rather than bit-mapped technology.



## 7.3 Experimental limitations

The main experimental limitation relates to the nature of the Adaptive Waterfall Model for Knowledge Acquisition and the time required to execute a number of iterations of that model. As described in chapter four, the nature of the Adaptive Waterfall Methodology is that a basic model of a subject domain (in this case the perceived utility of a piece of software) is iteratively refined by eliciting expert feedback. The Model provides a powerful way in which to elicit qualitative/insightful data, because the expert is being asked to comment on what they feel about the *experience* of using a piece of mapping software, rather than being asked what they *think* that they would feel about using a piece of mapping software. The Model starts by making a minimum of assumptions about what the investigator expects the expert is going to feel. An understanding is developed gradually, and is moulded during interactions with many users.

The problem with this methodology is that the elicitation and development of an understanding regarding how different users perceive the software being tested takes a lot of time. The methodology therefore (within a given time period) reduces the number of potential subjects who can be interviewed, and as a consequence reduces the extent to which the results may be generalised to a wider population. It sacrifices generality to maximise validity.

Nevertheless, the great size of the majority utilising an organic protocol for mapping, coupled with the variety of their backgrounds and wide range of computer experience, suggests strongly that a preference for organic protocol is a general phenomenon, and that a computer-based mapping application which supports such would be of great value.

There is scope for larger quantitative study around this conjecture and also around the questions of what might best facilitate the work of those using disclosure protocol, or working in groups. Two pilot studies in this direction are described in Appendix 3.

## 7.4 Adding new terms to the glossary

With respect to the glossary of terms introduced in Fig 3.1, the following terms were derived during a brief review of computer-based mapping applications in 1992. Those terms being: dynamic ideas, dynamic links, expand function, export map, export text, notice board access, idea mobility, paragraph text, notes, maximise work space, virtual work area, and zoom facility. From interaction and discussion with KwikSort users over a period of about 12 months, and from reflection on those interactions and discussions, it is now apparent that the initial glossary is too limited, and that at least twenty new terms now need to be added. With respect to dynamic links, there can be: **line links**; **arrow links**; **annotated links**; and **bit-mapped links**. With respect to ideas boxes, it should be noted whether the user has access to **easy input**, in which the user can input ideas with a single click of the mouse or the press of a single key; and whether the user has access to **in-place editing** or **bring to front / send to back** options. Output from applications is variable, so it is important to note whether an application has the facility for **high-grade printed output**, **bit-mapped output**, or **vectorized output**. In addition, some users will be interested to know whether an application provides them with **multiple shapes** in which to type ideas, **style sheets** to reduce the effort involved in controlling the appearance of text within a shape, and a **spell checker** to ensure that maps do not contain any embarrassing mistakes. The glossary must also include the new facilities developed during the implementation of KwikSort - these being the facility to hold ideas on a central **note pad**, and the facility to **autowrite** ideas between any pad and any map surface. With respect to text-based output, it is possible to generate a text file based on the text stored in a map or (as in ABC FlowCharter 1.13) to generate a written report based on the ideas stored in a map - two facilities which will be named **electronic report** and **printed report**, respectively. Also related to text is the ability to format text in terms of font, size, style, and alignment (**extensive text options**). In terms of graphics it should be noted whether a mapping application has access to all the usual options found in graphics applications, such as re-sizing and the group selection of ideas (**extensive graphics**

options). Finally, there are at least two protocols which may be utilised when constructing concept maps, **organic** and **disclosure**, which have been described previously. A third possibility is the **step protocol**, in which a mapper generates or imports all (or nearly all) their ideas, and then sorts those ideas. Although no KwikSort user reported utilising a step protocol, as the amount of data held in electronic form grows, this protocol is likely to become an increasingly attractive possibility.

## 7.5 Modern mapping applications

Three major computer-based mapping applications have been released since the original reviews were conducted in 1992. Each has something new to contribute to an understanding of the potential utility of computer-based mapping applications - and to what makes an efficient design for such applications. The three applications are: COPE, InfoMap and Visio. **Figure 7.1** shows a screen shot of COPE. The function of COPE is to enable users to create and trace causal chains, converting those chains from a map into a textual form (see Eden et al (1979) and Cropper et al (1990)). Having not seen the program in action, it is not possible to comment here on what the potential utility of such reasoning might be, particularly since the review software was a beta copy and came without a reference manual. However, the idea of providing a mapping application with a reasoning facility opens the way for other application designers to think of an electronic map as not simply an externalisation of the mappers' ideas, but as a way to support reasoning based on that map.

InfoMap is a mapping application, the design of which is based on stylisation of the map design popularised by Tony Buzan (see chapter two). The first impression when opening InfoMap is of a well-designed interface (see **Fig 7.2**). Although based on a Buzan style of mapping, the facilities in InfoMap play to the strengths of the Buzan way of working, and thus do not feel as constraining as the Mind Maps Plus program reviewed earlier. For a start, ideas are written on the horizontal, which makes them easier to read. New ideas are automatically arranged on the network as it grows. In addition to the design ideas outlined, InfoMap presents three facilities which the author had not seen in any other computer-based mapping application: context sensitive help, a definable zoom facility, and export as a text file. Although the first two facilities are not new in computing terms (in applications such as graphics packages and word processors), it was the first time the author had seen these facilities implemented in a mapping application. The definable zoom facility was especially useful, because as the map grew, it allowed the size of text to be

shrunk using a number of user defined or predefined levels of magnification - enabling an A4 sized map to be easily edited on a VGA screen.

A screen shot of Visio is shown in **Figure 7.3**. Visio is a relatively new mapping application, based on the idea of drag-and-drop graphics. As with InfoMap, the interface has been well designed - with plenty of context sensitive help, and the facility to use the right-hand mouse button to activate context-sensitive pop-up menus. The use of the right-hand mouse button to activate menus reduces the amount of distance the mouse has to travel to access commonly used menu options. Overall, Visio can be described as a program which seeks to integrate the ideas found in graphics applications with the ideas found in charting application, to provide a set of facilities which ease the construction of concept maps. The final point to note about Visio is that it is the first program to implement Microsoft's OLE2-automation, which gives mappers the option to write macros in OLE2-compliant languages such as Visual Basic 3.0.

Fig 7.1: A screen shot of the computer-based mapping application COPE

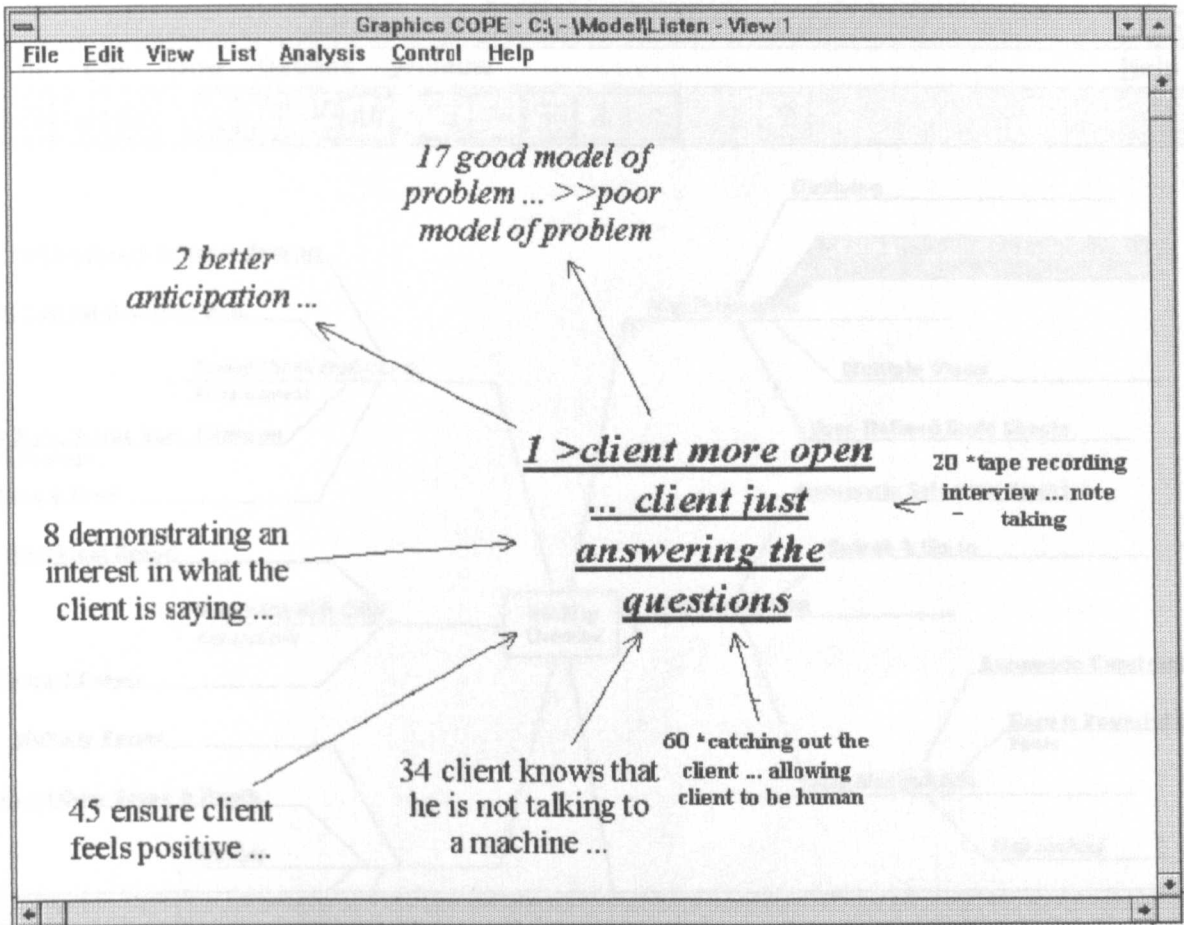


Fig 7.2: A screen shot of the computer-based mapping application InfoMap

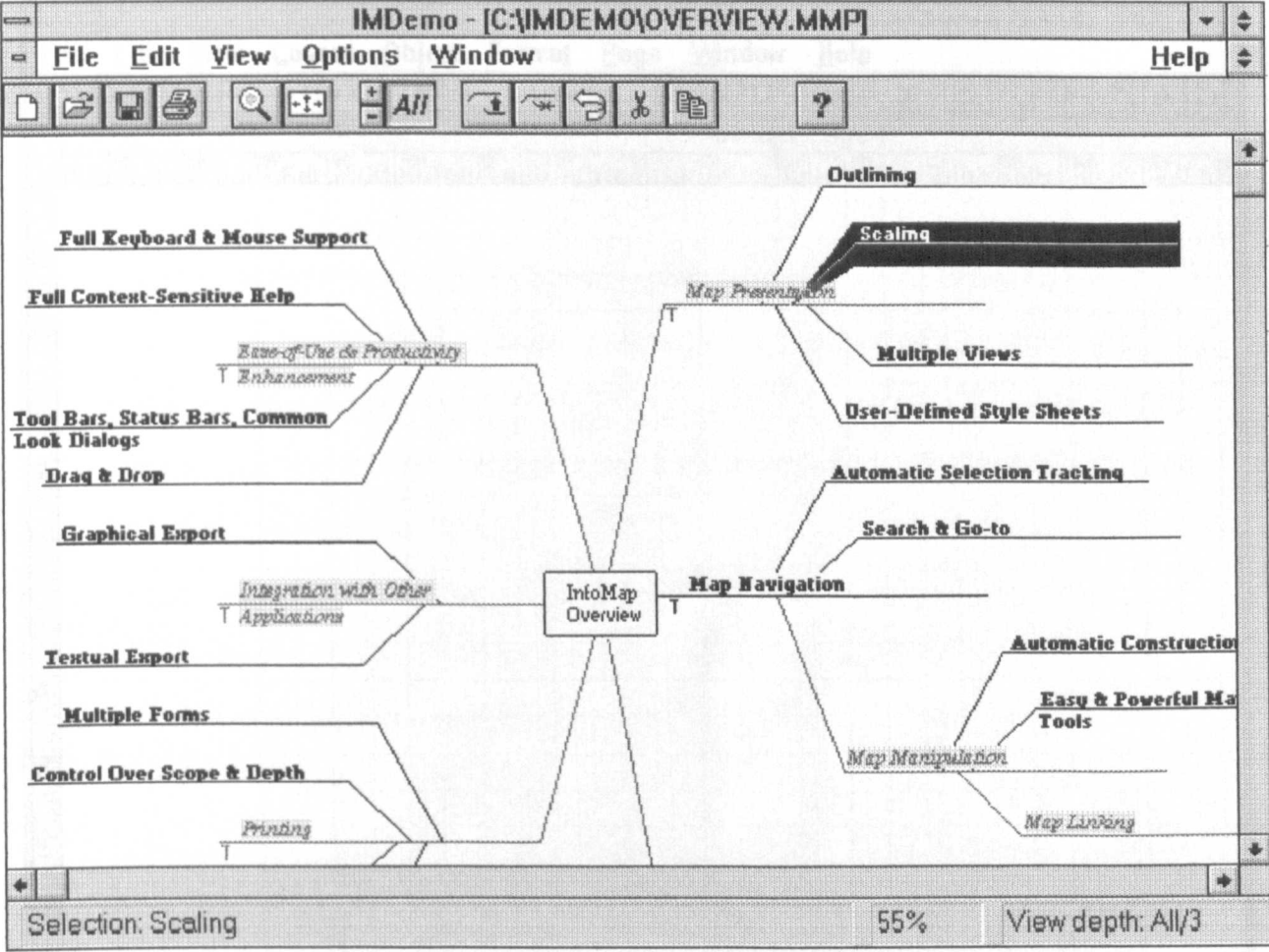
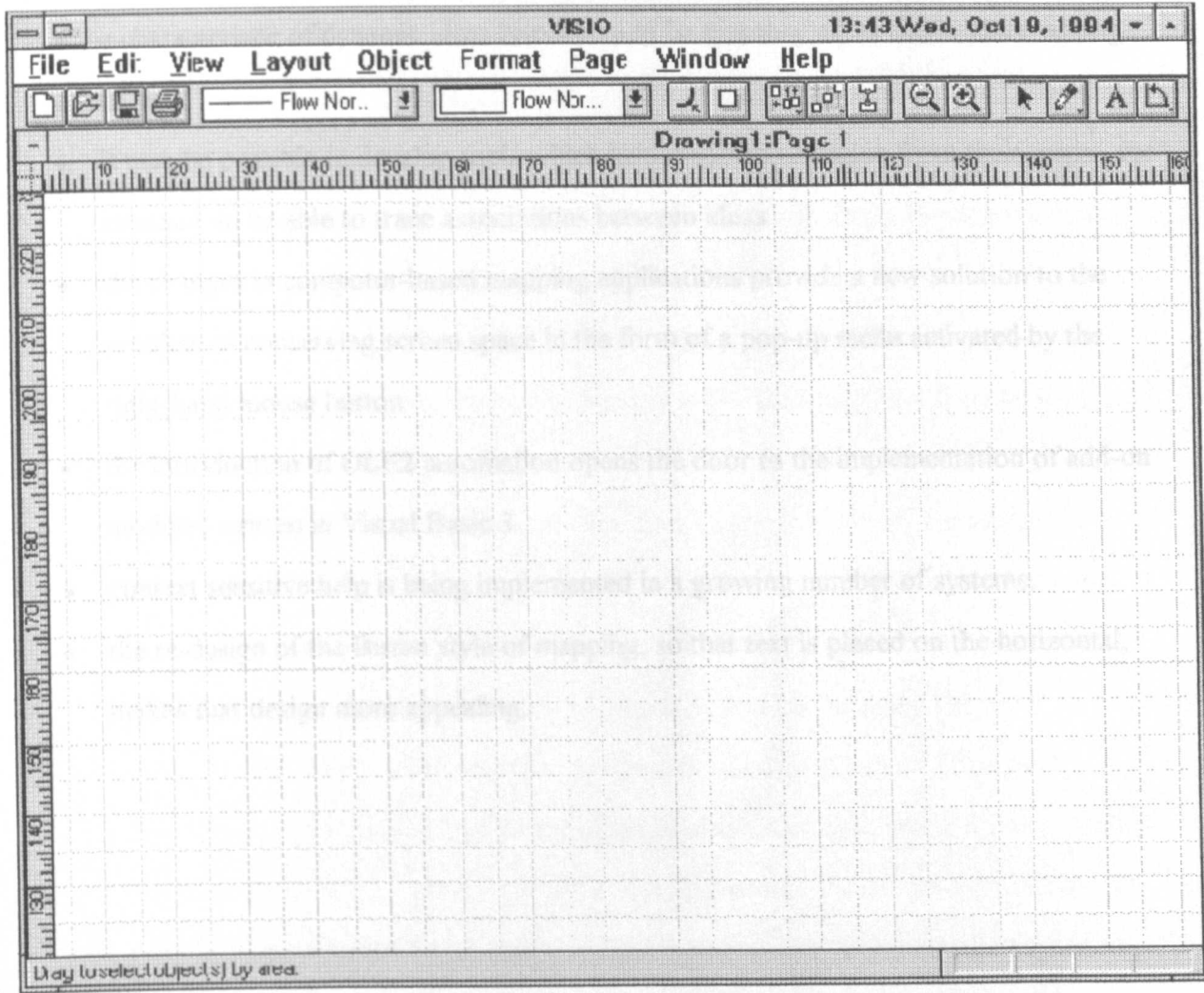


Fig 7.3: A screen shot of the computer-based mapping application Visio





The following is a summary of the issues raised by the new generation of computer-based mapping applications. These issues are six-fold:

- a characteristic of dynamic ideas boxes should be that they allow the in-place editing of text
- it may be possible to develop tools which help mappers to reason from their maps - for instance, to be able to trace associations between ideas
- the changes in computer-based mapping applications provide a new solution to the problem of conserving screen space in the form of a pop-up menu activated by the right-hand mouse button
- the introduction of OLE2 automation opens the door to the implementation of add-on modules written in Visual Basic 3
- context sensitive help is being implemented in a growing number of systems.
- the re-design of the Buzan style of mapping, so that text is placed on the horizontal, makes that design more appealing.

## 7.6 Adding more terms to the glossary

Based on the summary of the new features to be found in mapping applications released since 1992, the list of terms which could be used to describe and contrast computer-based mapping applications has to be updated. The new items to be added to the glossary of mapping terms are: **context sensitive help**, **auto-place Buzan links**, **horizontal Buzan links**, **context-sensitive pop-up menus**, **reasoning facilities**, and **OLE2 compliance**. In addition, in the time between an analysis of the KwikSort results (discussed in section 7.4) and the review of new mapping applications (reported in section 7.5), it became apparent that there are four other facilities which would facilitate the mapping process. These facilities have not been discussed because they do not appear in any of the mapping applications yet reviewed. The four new facilities might be termed grid input, template support, ideas' pad and record/recall. **Record/recall** is an extension of the style sheet idea. It allows a user to record the appearance of one ideas box and to apply the characteristics of that box to their boxes. With regard to the generation of ideas on an **ideas pad**, currently the note pad in KwikSort provides users with a word-processor field onto which they can brainstorm. With a little extra work, the functionality of the field could be increased, by programming the mapping application to support a number of common creative thinking techniques, such as those devised by Edward De Bono. **Template-support** would compliment the use of creative-thinking tools: in addition to helping people to use structured thinking techniques to generate ideas, mapping applications with a high level of presentational quality could provide pre-defined templates for common mapping problems. Finally, with regard to **grid input**, such input would enable those who find a computer screen too constraining a work space, to concept-sort on a grid on a table top, and to then print that concept map by typing in ideas and grid coordinates.

Amalgamating all the terms introduced in this thesis, the final glossary of mapping terms is presented in **Appendix 2**. This glossary is intended to provide a foundational set of terms with which computer-based mapping applications can be discussed and evaluated. The

glossary also provides a basis for the production of a checklist, which might be used by designers and would-be users who want to check the utility of a particular facility or application in terms of a set of specified mapping needs.

## 7.7 CBMA-Checklist

One of the impressions gained in the course of the research reported in this thesis was that most people know very little about the use of map-like visual organisers, and even less about using a computer to construct concept maps. The respondents of a small pilot study of staff and students at the Open University suggested that of those who know about the use of map-like visual organisers, most know very few mapping techniques, and often used inappropriate mapping media (see **Appendix 3**). In addition, it became apparent from the literature reviews, the reviews of software, and the KwikSort user feedback, that to evaluate the utility of a computer-based mapping application, many factors have to be taken into account.

With these problems in mind, it was decided that the best way to express the issues affecting the utility of computer-based mapping applications would be in the form of a checklist. A checklist could be used by software designers to outline the design of a proposed computer system, and by users who want to decide what kind of system would best suit their mapping needs. Since the purpose of the checklist was to enable people to assess the utility of a computer-based mapping application with regard to specified mapping goals, the checklist was called the Computer-Based Mapping Application Checklist - or CBMA-Checklist for short. The initial form of the checklist (completed in March 1994) is presented in **Appendix 4**. This version of the checklist was filled out and used to guide the design and development of a process-based mapping application called BrainBox, which was planned as a response to the feedback provided by KwikSort users (see **Appendix 4**). During the development of BrainBox a number of presentational features of the checklist were improved. The final form of the checklist (which was completed in June 1996) is presented in **Appendix 5**.

## 7.8 BrainBox

In order to demonstrate the kinds of process-based facilities which were requested by mappers who used KwikSort, it was decided to use the CBMA-Checklist to guide the development of a Windows-based application called BrainBox (and in conjunction with BrainBox a Macintosh application called HyperMap). Based on the design outline presented in **Appendix 4**, BrainBox was implemented in the Visual Basic language, running under Windows 3.1 on a PC. The following text describes this implementation and presents a set of screen shots illustrating the program.

The basic screen layout in Brainbox provides the user with a blank window, which by default maximises to fill the screen space available. The only object in that blank space is a single ideas box (see **Fig 7.4**). The menu is accessed by pressing the right-hand mouse button. (see **Fig 7.5**). A box is moved by 'mouse-down and drag', which enables users to move the box anywhere within the work space. Clicking on the box inserts the text cursor, allowing text to be edited. The easiest way to input an idea is to press the return key. Pressing the return key causes a new box to be made and the text cursor to appear in that new box.

If a number of ideas need to be generated, the user might like to use the FreeThought module (see **Fig 7.6**). In the FreeThought module, the user is provided with a set of templates which enable them to use any one of fourteen different creative thinking techniques to generate ideas. New ideas may be stored on a special note pad (see **Fig 7.7**). Two more pads, an import pad and an export pad, are also available on which to store ideas. Both these pads are identical in appearance to the note pad.

Having generated a set of ideas, those ideas will need to be sorted. Sorting is facilitated by the ability to apply colour to boxes and text and by the ability to vary the size and style of text. Styles may be set with the default screen (**Fig 7.8**), or by using the record/recall

menu options. Sorting is also eased by the facility to have selected boxes automatically come to the front of the screen, and through the use of the autowrite facility.

A Brainbox file can contain up to ten maps. Anyone working in a multiple-map file will find the powerful autowrite facility extremely useful. Having activated the autowrite dialogue box (**Fig 7.9**), clicking on any of the map/pad names on the list in the top right of the autowrite pad creates a list of all the ideas on that map, and displays that list on the left of the autowrite pad. Clicking on one of the ideas on the left-hand list copies that idea to the map surface (or to the export pad, depending on the settings the user has defined). Thus, the BrainBox autowrite facility enables text to be transferred between maps, or translated between map-based and list-based formats, far more quickly than any of the autowrite facilities implemented in KwikSort.

Having sorted ideas, links can be drawn between those ideas. The links are vector based and selected by mouse clicking. Once selected, there are menu options to alter the thickness and style of the line, and to add an optional arrowhead. In addition, there is also a record/recall menu option to allow the attributes of one line to be quickly copied to other lines. With regard to output facilities, Brainbox is capable of outputting a map in bit-map format, and is able to provide high-quality printed output (**see Fig 1.3-1.9**).

Finally, for those who want to use table-top concept sorting as a form of group decision support, and then input the results of that concept sorting, GroupMap (**Fig 7.10**) enables a map to be recreated by running a dialogue-driven input. The input asks the user to type the idea and the X and Y co-ordinates of that idea in millimetres. Using 40mmx40mm squares on an A2 work surface, or 80mmx80mm on an A0 work surface, GroupMap enables a group map to be reduced to the size of an A4 sheet of paper.

Fig 7.4: A screen shot of an empty map surface menu active

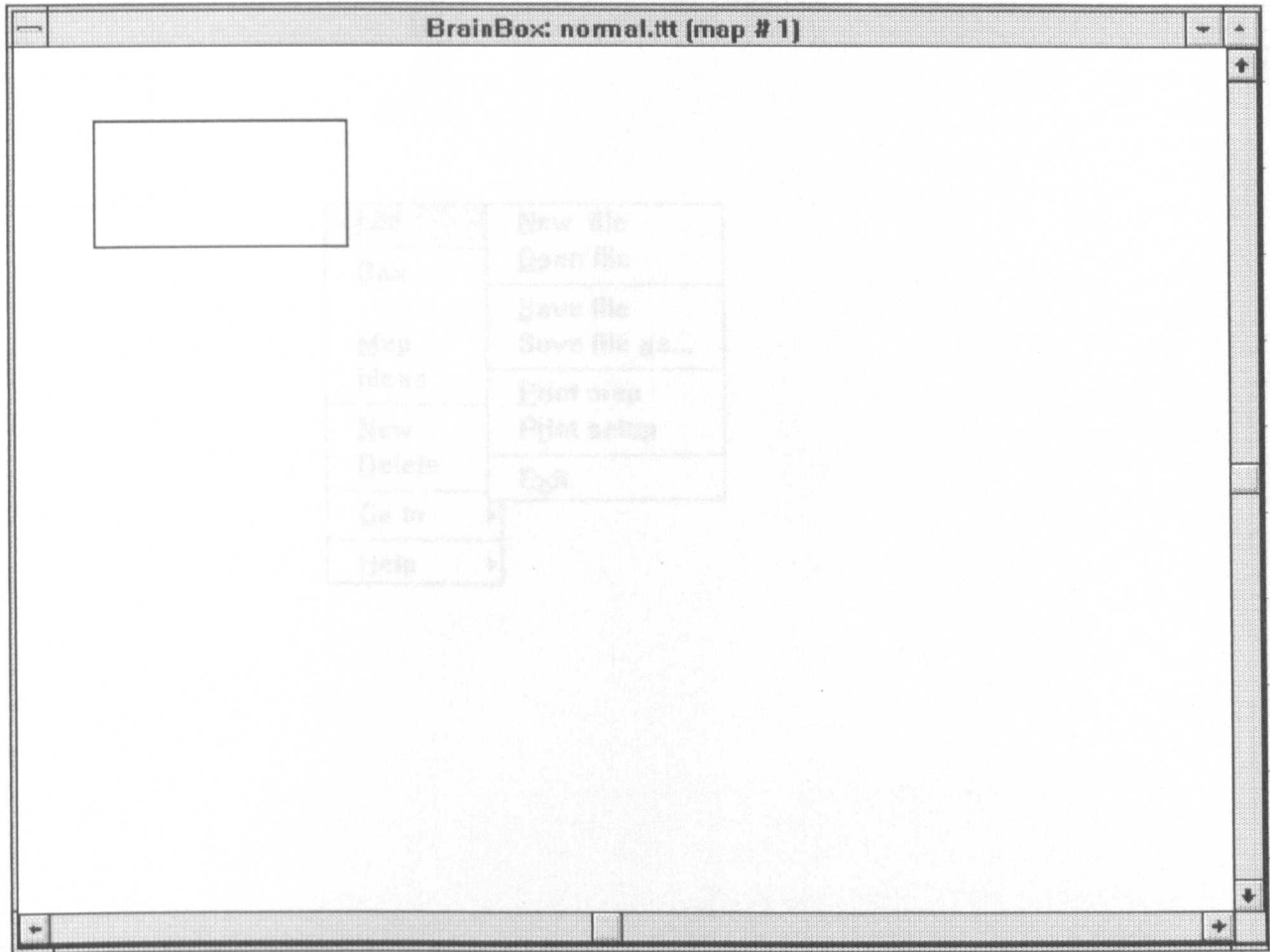


Fig 7.5: A screen shot of an empty map surface with the pop-up menu activated

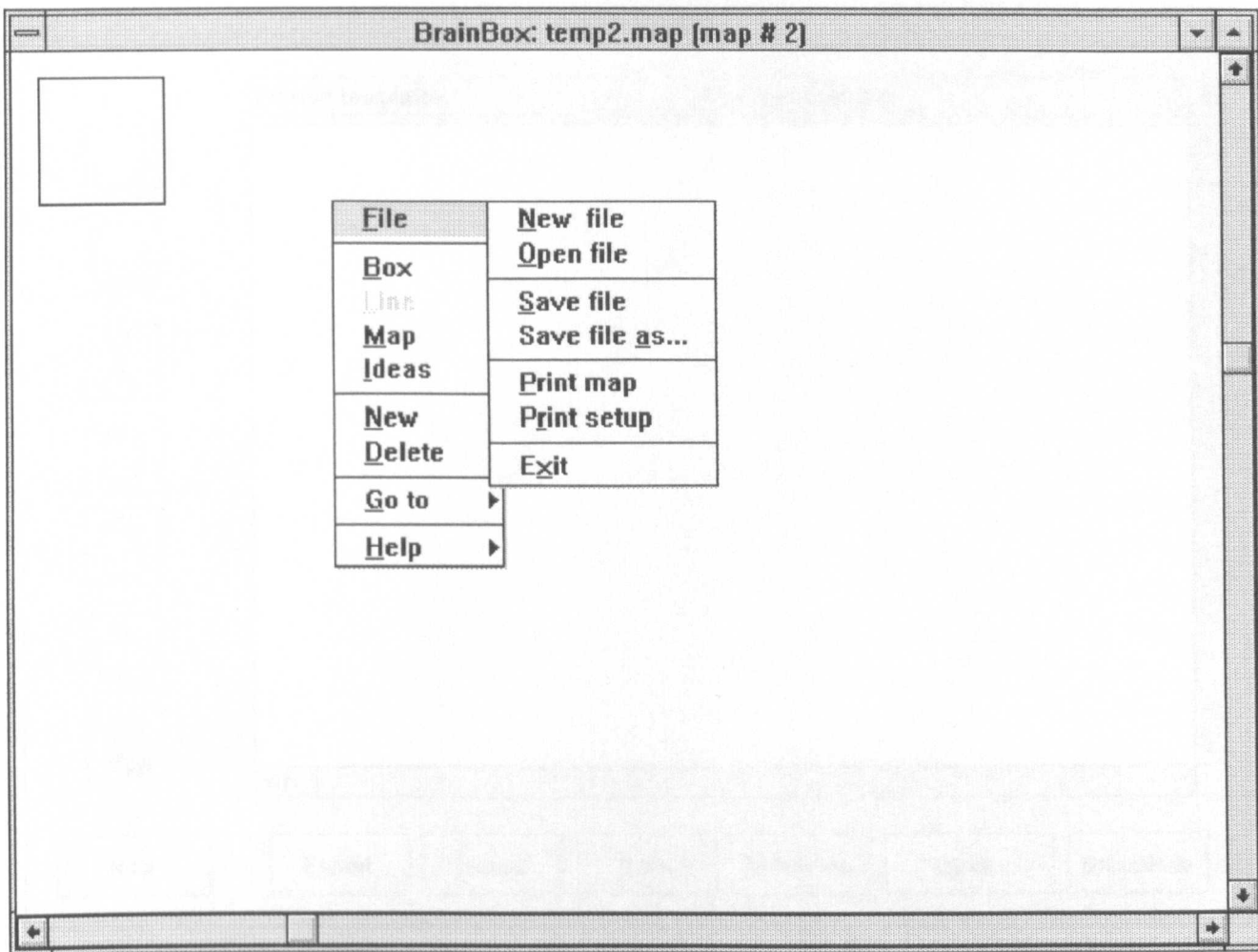




Fig 7.6: A screen shot of the FreeThought window

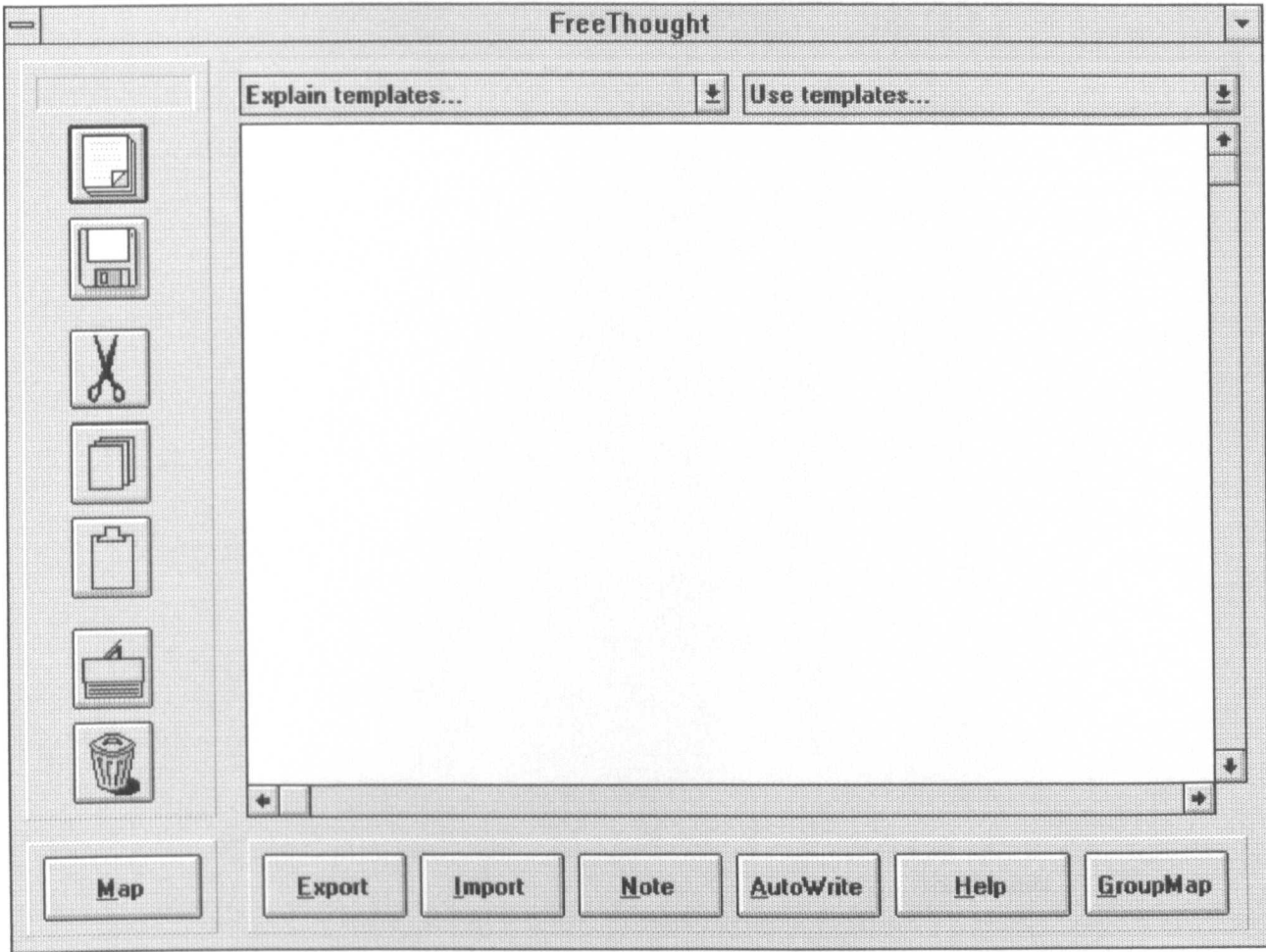


Fig 7.7: A screen shot of the note pad window

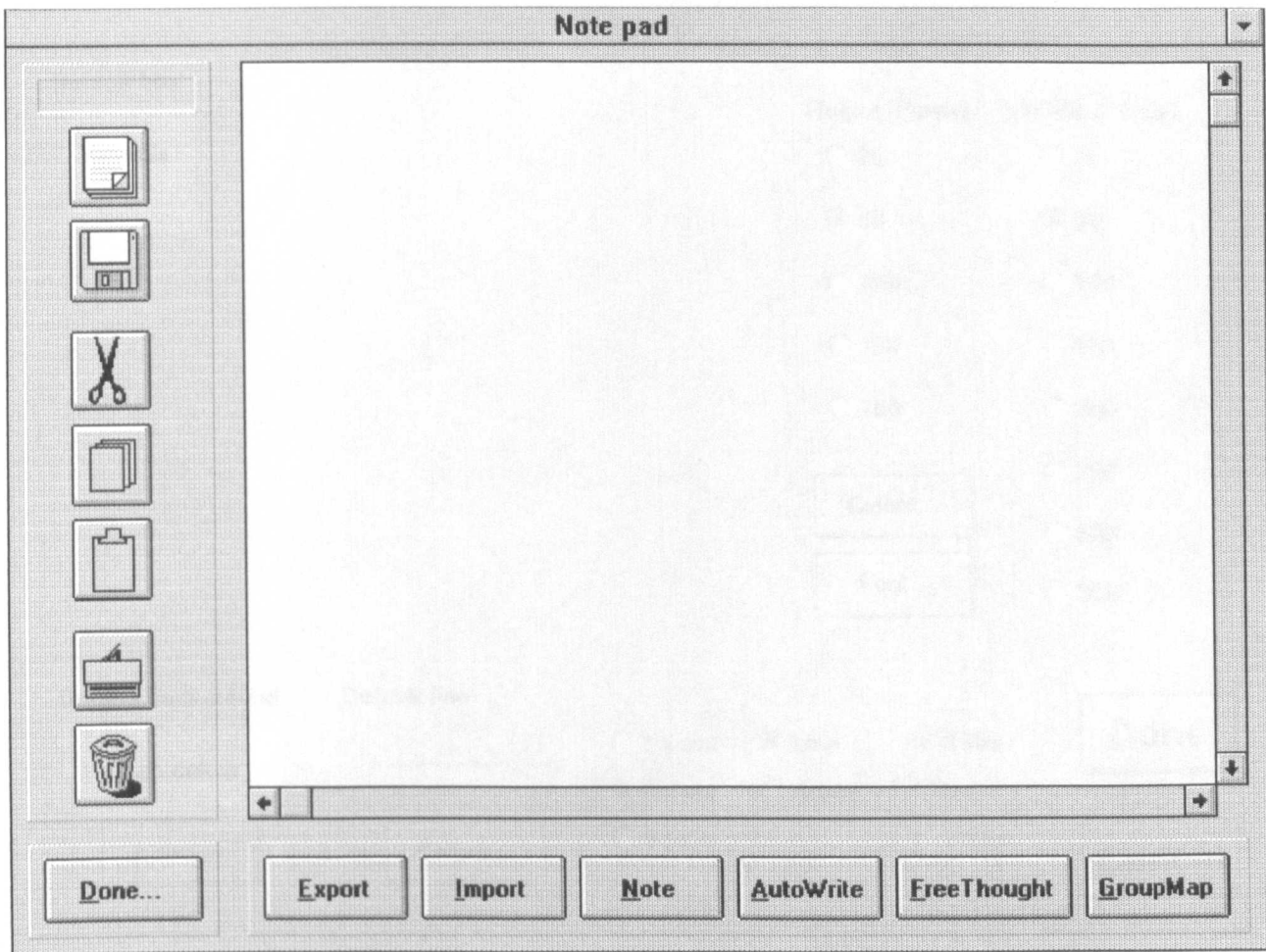


Fig 7.8: A screen shot of the set defaults window

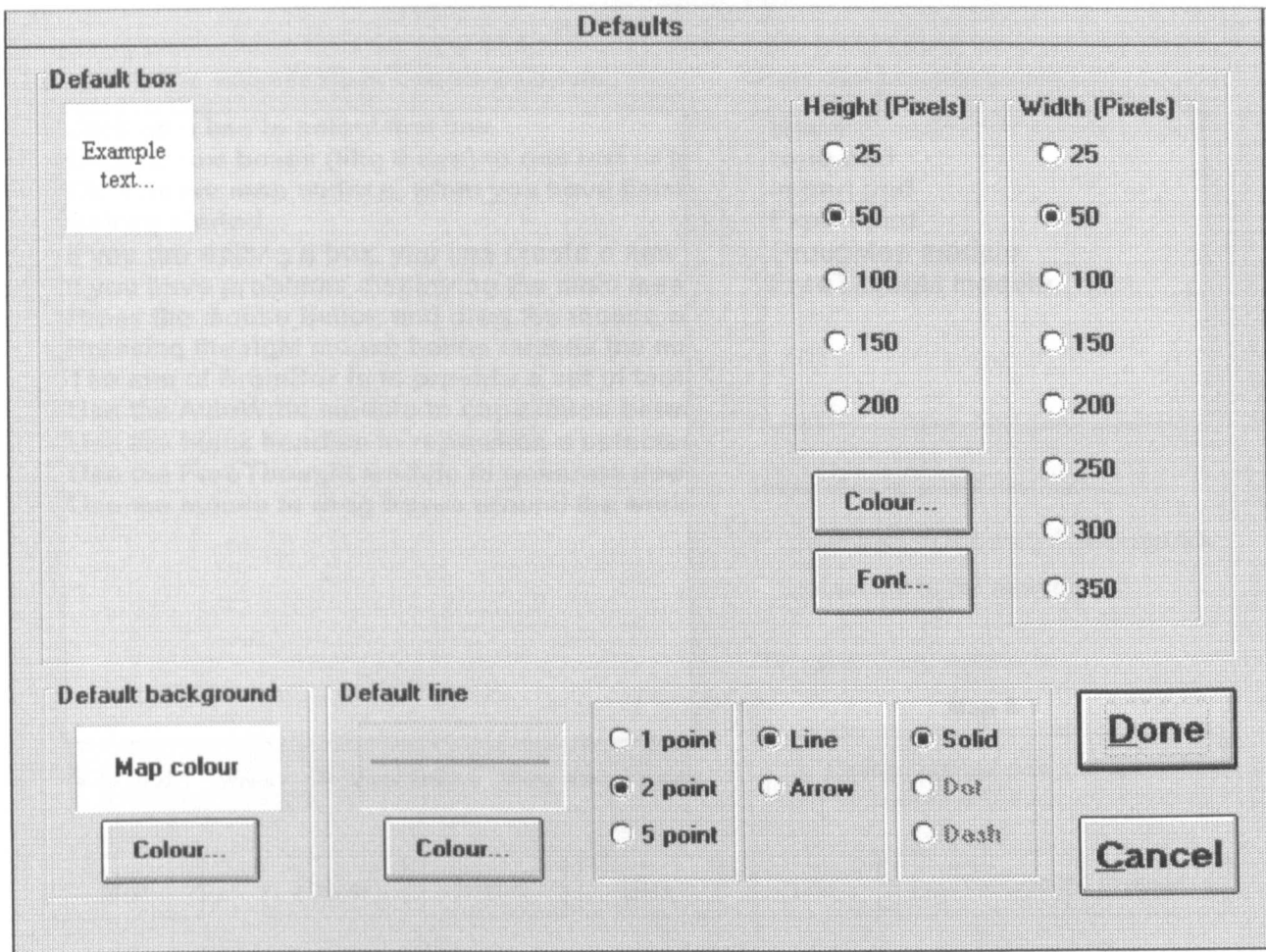


Fig 7.9: A screen shot of the AutoWrite window

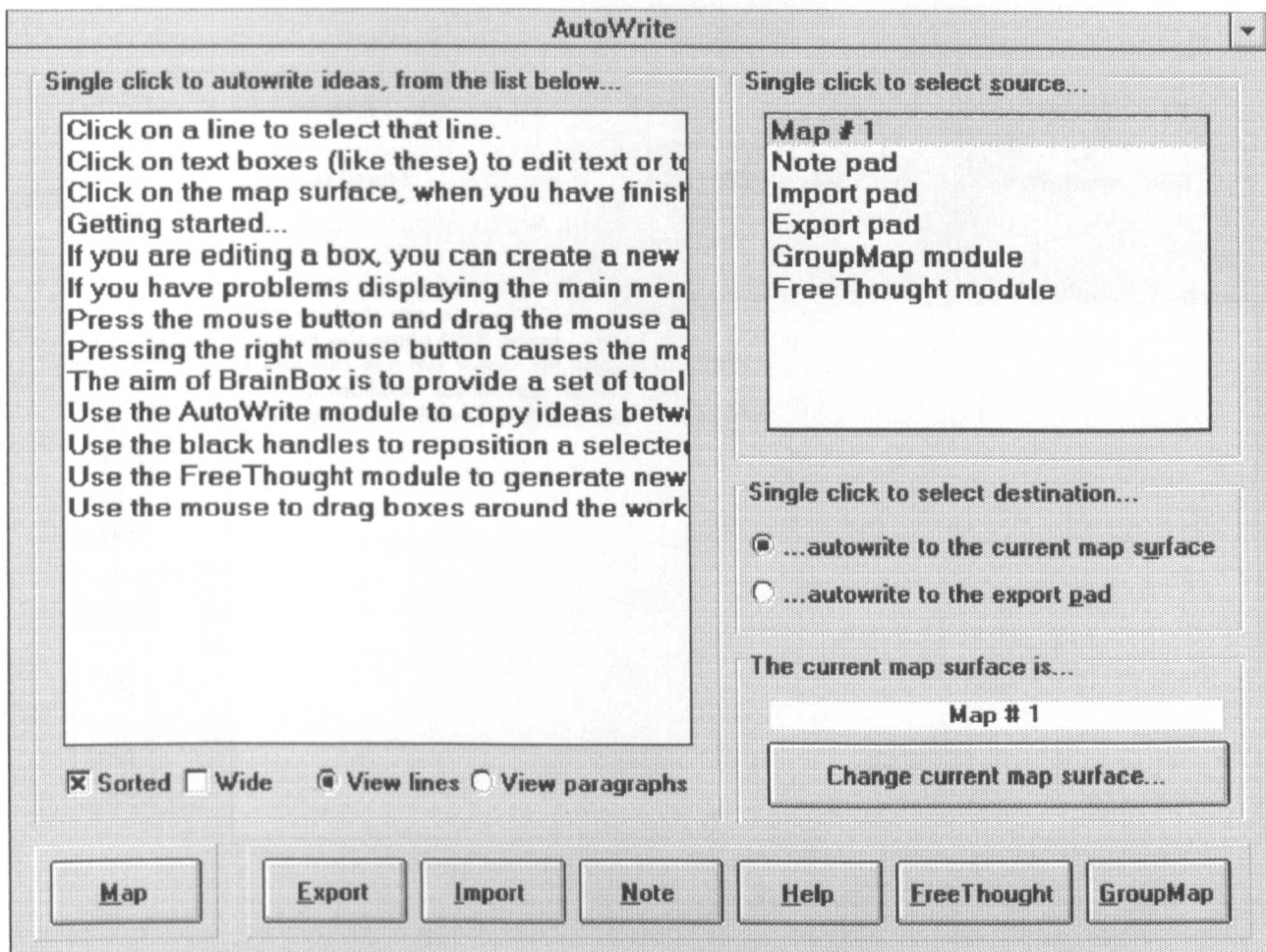
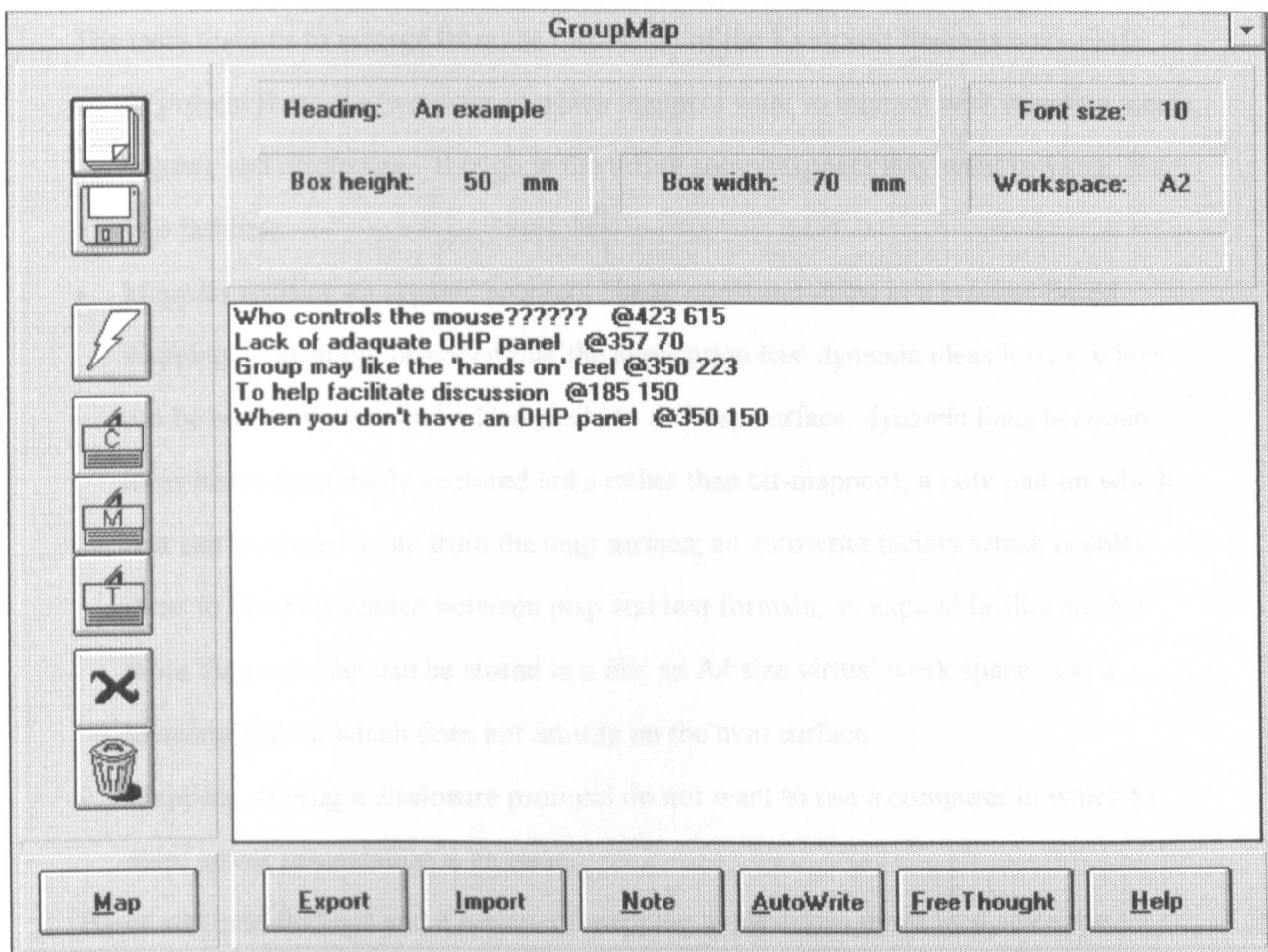


Fig 7.10: A screen shot of the GroupMap window



As a study into the glossary of mapping terms introduced in chapters two and three, and as a means to help people know how, if any, mapping techniques, this glossary was developed. The result of the theoretical and practical work conducted in this thesis, in the form of a checklist. This checklist, termed the Computer-Based Mapping Application Checklist (or CBMA-Checklist), enables people to work out their mapping needs, and to assess the quality of computer-based mapping applications with respect to these needs. This checklist was used to develop BrainBox (and its Macintosh cousin HyperMap). The checklist is available to all users, and provides a means for users to provide feedback, and provide a means for users to evaluate the practical worth of the procedures requested by BrainBox users.

## 7.9 Summary

The main features to emerge from the discussion of the KwikSort findings were these:

- At present there are two ways in which mappers want to interact with mapping media, *organic* and *disclosure* - though in the future some mappers may want to work in a *step* fashion.
- Mappers utilising an organic protocol like to construct maps in a process-based mapping application, provided that the application has: dynamic ideas boxes, which can be edited in place and added easily to the map surface; dynamic links between ideas boxes (preferably vectored links rather than bit-mapped); a note pad on which text can be stored away from the map surface; an autowrite facility which enables ideas to be easily copied between map and text formats; an expand facility so that more than one map can be stored in a file; an A4 size virtual work space; and a menuing system which does not intrude on the map surface.
- Mappers utilising a disclosure protocol do not want to use a computer in which to map, unless presentation is an issue.

Based on these findings and a review of mapping applications developed since the KwikSort study, the glossary of mapping terms introduced in chapters two and three was updated. Since most people know few, if any, mapping techniques, this glossary was used to present the results of the theoretical and practical work conducted in this thesis, in the form of a checklist. This checklist, termed the Computer-Based Mapping Application Checklist (or CBMA-Checklist), enables people to work out their mapping needs and to assess the utility of computer-based mapping applications with respect to these needs. This checklist was used to develop BrainBox (and its Macintosh cousin HyperMap). The aim of BrainBox is to act upon the feedback provided by KwikSort users, and provide a working system with which future users may evaluate the practical worth of the process-based tools requested by KwikSort users.

# Chapter Eight

## Conclusions

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## 8.1 What was achieved

From the investigation of the issues affecting the utility of computer-based mapping applications, nine achievements have been attained.

- A glossary has been developed of terms which enable the process of constructing concept maps to be described in more detail than has previously been possible. For instance, it is now possible to describe different mapping goals, identify the mapping needs associated with different mapping goals and identify the best combination of map designs and mapping media with which to attain a particular mapping goal.
- A review of existing mapping applications has found that most currently available commercial mapping applications focus on mapping as a product-based activity, rather than a process-based activity.
- A prototype mapping application called KwikSort has been designed to investigate the kinds of process-based tools which facilitate the generation and sorting of ideas.
- The results of the KwikSort study indicate that there is a core set of tools which affects the utility of mapping applications - in terms of generating and sorting ideas. The core set of facilities consists of: dynamic ideas boxes (which may be added to the map with a single mouse click or key stroke, and which allow in-place editing), dynamic links, an expand facility, an A4 virtual work space, note pad(s), and an autowrite facility.
- The Computer-Based Mapping Application Checklist (or CBMA-Checklist) has been developed. The checklist is of use to those designing new applications, and to those who need to select (and if necessary customise) an existing application.
- A new application called BrainBox has been implemented in Visual Basic 3.0 Professional for Windows (and was released as shareware in early 1995 and freeware in early 1996). The aim of BrainBox is to illustrate the utility of a computer-based mapping application based on concept sorting.



- A HyperCard version of BrainBox has been implemented for the Macintosh computer (and has been available as freeware since early 1995).
- The results of the KwikSort study indicate that there are at least two ways in which mappers can choose to construct their maps - *organic* and *disclosure*, where the *organic* protocol involves generating and sorting a few ideas at a time, using a map as a form of *mental scaffolding*, while the *disclosure* protocol involves developing a mental image of the way in which ideas relate to one another, in effect using the product of the mapping process as an *aide-memoir*.
- The results of the KwikSort study indicate that the main issue which affects the potential utility of a computer-based mapping application, is the way in which the mapper interacts with the medium in which the map is drawn. In terms of currently available technology, those utilising an organic protocol like a computer-based mapping medium, because the organic protocol is dynamic and supports the generation and sorting of ideas; in contrast, those utilising a disclosure protocol dislike using a computer-based medium, because they find that typing and using a mouse takes more time than sketching out a map on a sheet of paper, and thus that using a computer interferes with their flow of thought.

Of the nine achievements listed above, the two most useful from a theoretical perspective are the development of a glossary of terms relating to the process of mapping, and the identification of two main ways in which mappers interact with mapping media. Both these developments provide a foundation on which future empirical research can build. For instance, it would be interesting for future researchers to develop more kinds of templates and to help mappers to develop their own templates. It would also be interesting for future researchers to identify what cognitive styles underlie the ways in which mappers interact with mapping media, and indeed whether there are more ways of interacting with mapping media than the two currently identified. One additional possibility might be termed 'step mapping'. As more people use electronic media, there

may come a time when mappers want to import large amounts of textual data into mapping applications, split it into separate ideas, and sort these ideas into natural clusters.

From a practical perspective, the most noteworthy achievements are the development of the CBMA-Checklist and the implementation of both Macintosh and PC based software. Taken together, the nine achievements provide future researchers with a set of practical tools with which to conduct further research into the utility of computer-based mapping applications.

## **8.2 Future research**

There are a number of issues which emerge from the work reported in this thesis, which future researchers might like to pursue. The issues emerging from this research can be grouped under three headings: (i) investigations which might be conducted by social anthropologists and social psychologists; (ii) investigations which might be conducted by linguists, designers, and philosophers; and (iii) investigations which explore the work started here in a more quantitative manner.

### **8.2.1 Investigations which might be conducted by social anthropologists / social psychologists**

More work needs to be done to assess and discern possible mapping goals. Of particular interest would be the use of maps to attain group goals. With this in mind, social anthropologists might undertake a series of case studies. Case studies could explore the ways in which maps affect the transaction of ideas between people. Maps have been shown to positively affect transactions, but - how does this effect occur? And, how might it be maximised?

In terms of maximising the effectiveness of maps as a form of social interaction, there might be an exploration of the ways in which different map designs and mapping media affect communication between people. Two possibilities immediately spring to mind. Firstly, French researchers (Gardin 1988:168) have suggested that different experts often have different models of a subject domain, models which lead to different interpretations of the evidence before them. An obvious question which arises from this work is: How might maps help experts identify their differences and work to overcome those differences? Some work has already been done in this area, for instance Zimmer (1984) and Lagrange/Renaud (1988), but as the number of ways of representing knowledge grows and the sophistication of computer technology increases, there will undoubtedly be

fresh insights to be made. Secondly, computer technology is increasingly enabling work groups to be geographically distributed across national and international boundaries. How might maps enhance the technology of electronic conferencing, helping people to understand one another - particularly when those people may come from different cultures and speak a different language?

### **8.2.2 Investigations which might be conducted by linguists / designers / philosophers**

As representations of ideas, maps should be made the subject of semiological analysis - which might interest researchers who come from a background of linguistics, design and philosophy.

The map designs favoured in this thesis focus the mapper on the holistic aspects of the domain being mapped. How does the information conveyed by a holistic representation differ qualitatively from the information which might be conveyed in a traditional (verbal) text? With this question in mind, designers might like to experiment with different map-based / text-based documents. They might like to consider the question: Which map designs communicate most effectively and in which contexts? At the same time, philosophers and linguists might like to consider the implications of different map designs. At a time in which the reductionist paradigm is under attack in the face of non-linear systems theory, do maps offer a better form of representation for use when describing and reasoning about chaotic systems?

### **8.2.3 Investigations which explore the work started here in more detail.**

Clearly, much of the work reported in this thesis is qualitative. A number of issues have been unearthed, which would be worthy of additional investigation - of both a qualitative and quantitative nature. For instance:

- More work could be done to investigate the utility and application of template designs.
- BrainBox needs to be made available to users so that the utility of the process-based facilities it offers can be commented on.
- A large number of people in business and education need to be interviewed to find out what percentage of people know how to use maps, and of those who do, which mapping goals, map designs and mapping media are most often used.
- Users of existing computer-based mapping applications, such as ABC FlowCharter and Visio, need to be interviewed to find out mappers' opinions of these applications and to find out if mappers have a wish-list of facilities to extend these programs' functionality. The reality of mappers' wishes could be tested by using Visual Basic to create add-on modules which mappers could then comment on.
- Groups of people who have access to both Thinking With Hexagons and C.K.Modeller need to be identified, so that they can comment on how they choose between the two techniques and what influences their choice of mapping medium.
- A large quantitative study is needed to investigate the conjecture that, given the availability of easy-to-use dynamic mapping media, the great majority of all concept maps will be produced using the organic protocol.
- Further studies are needed to determine how the disclosure protocol can best be facilitated, and to develop effective software for facilitation of concept mapping in groups.

## 8.3 Final conclusions

The work reported in this thesis breaks new ground. The work can be described as an example of research and development going hand in hand. The work has been both ‘exploratory’ and ‘problem solving’. To be precise:

- **In terms of ‘exploration’:**

- An extensive literature review was undertaken.
- A significant sample of people was surveyed in order to ascertain the *perceived* needs of those engaged in mapping.
- The software currently available to draw maps was surveyed in order to assess the utility of computer-based mapping applications, with respect to the perceived needs of mappers.
- A prototype computer-based mapping application was developed to act as a focus for mappers' comments.
- As a result of feedback from users of the prototype computer-based mapping application, it was discovered that by far the most common way in which they create maps is to generate and sort a few ideas at a time. This protocol was termed *organic*.
- Users of the organic protocol were found to value greatly a computer-based mapping application which enabled them to generate concepts without limit, move them around freely, and connect them easily.
- Two further protocols were identified: *disclosure* and *step*. ‘Disclosure protocol’ refers to a process in which the mapper prepares a map in their ‘minds eye’, before sketching that map externally. ‘Step protocol’ refers to a process in which the mapper generates a set of ideas in an external medium prior to constructing a map.
- A set of criteria was identified with which future researchers can discuss aspects of the processes and products related to the construction of concept maps.

- **In terms of problem solving:**

- A checklist was devised, whereby mappers and designers might more easily assess the utility of a particular computer-based mapping application.
- The perceived needs of mappers were used to drive the design and implementation of working software, with which mappers might more easily conduct concept sorts and produce concept maps.

# **Appendix 1**

## **Examples of output from KwikSort**

The following pages provide 15 examples of concept maps drawn using KwikSort 1.5. Permission to use the maps was kindly given by a number of mappers using KwikSort on a computer at the Fairlight Christian Centre in Tooting. The subjects mapped are varied. Subjects include the preparation of sermons, project work by a student teacher, lesson preparation by a Tear Fund educator teaching about third world issues, an educator teaching about group dynamics, the preparation of a story line for a short story, and lesson plans by an English teacher.



Fig A.1.1: The top-level map in a set drawn by User K relating to group work

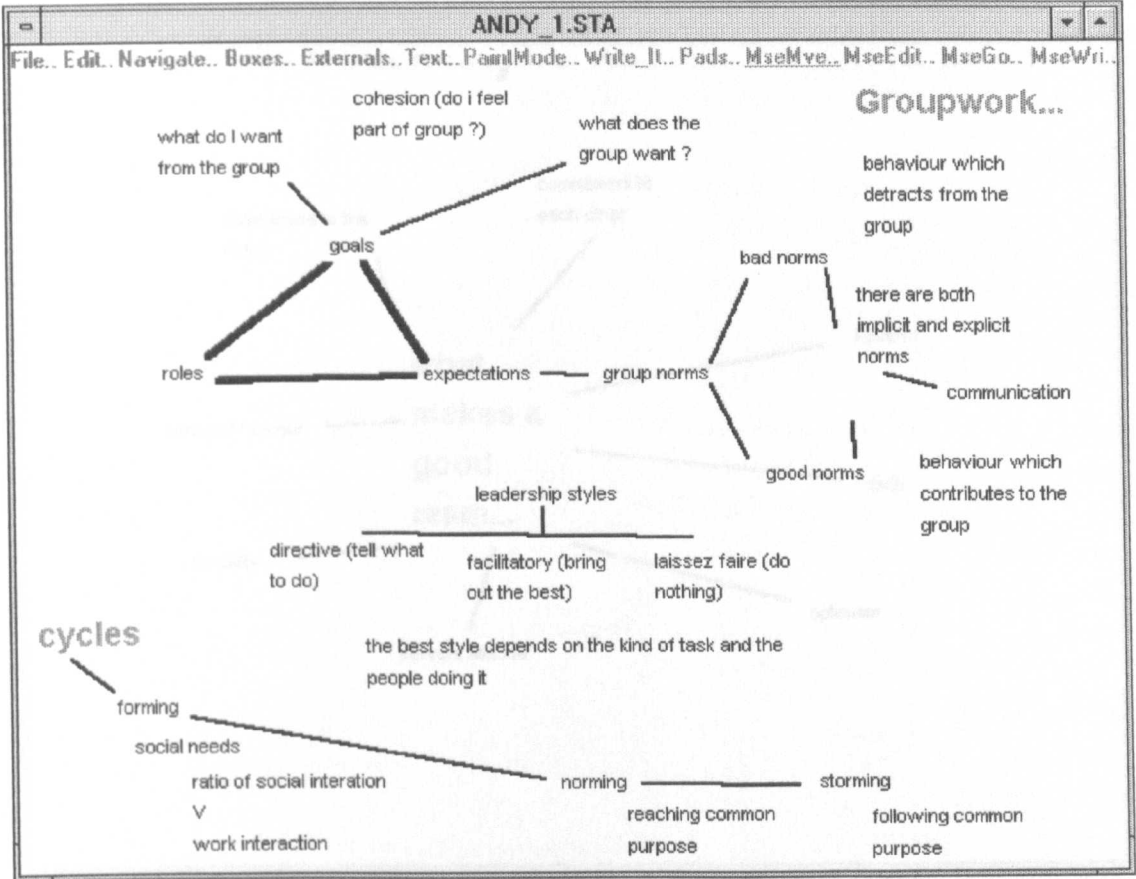


Fig A.1.2: A sub-map in a set drawn by User K relating to group work

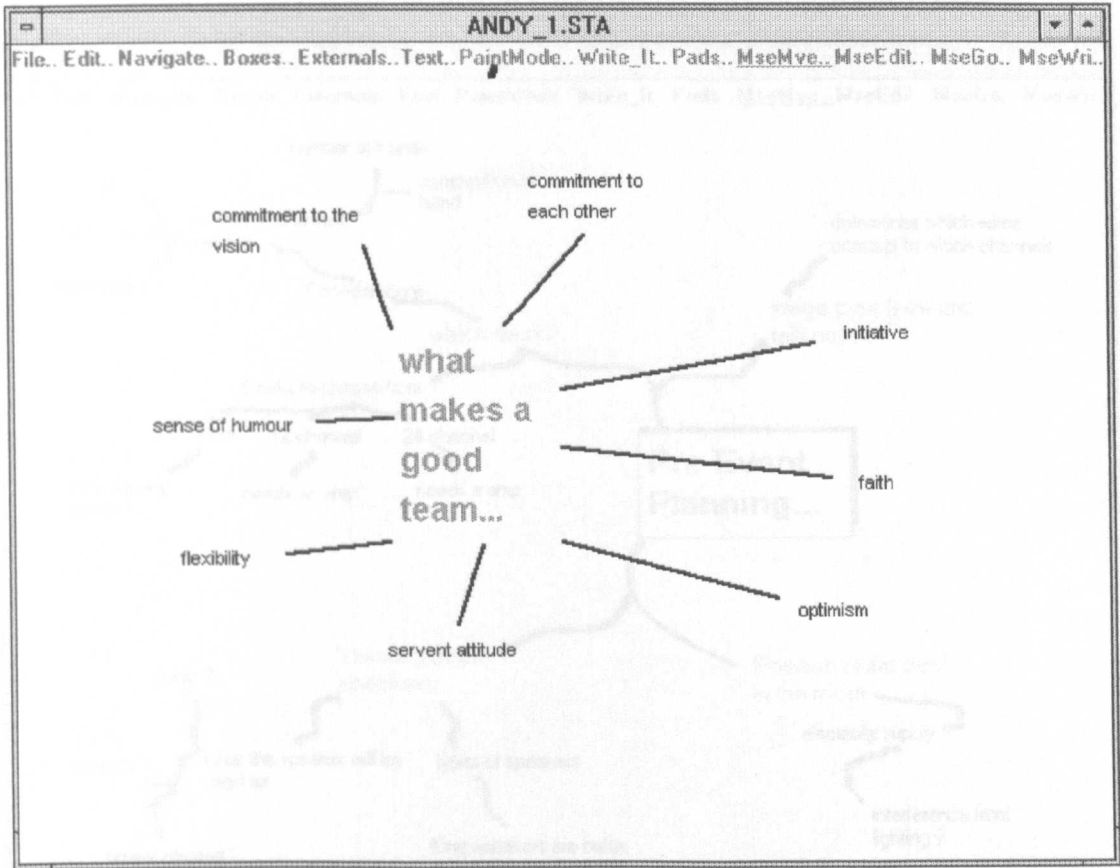


Fig A.1.3: A single map drawn by one of the centre's members - User L

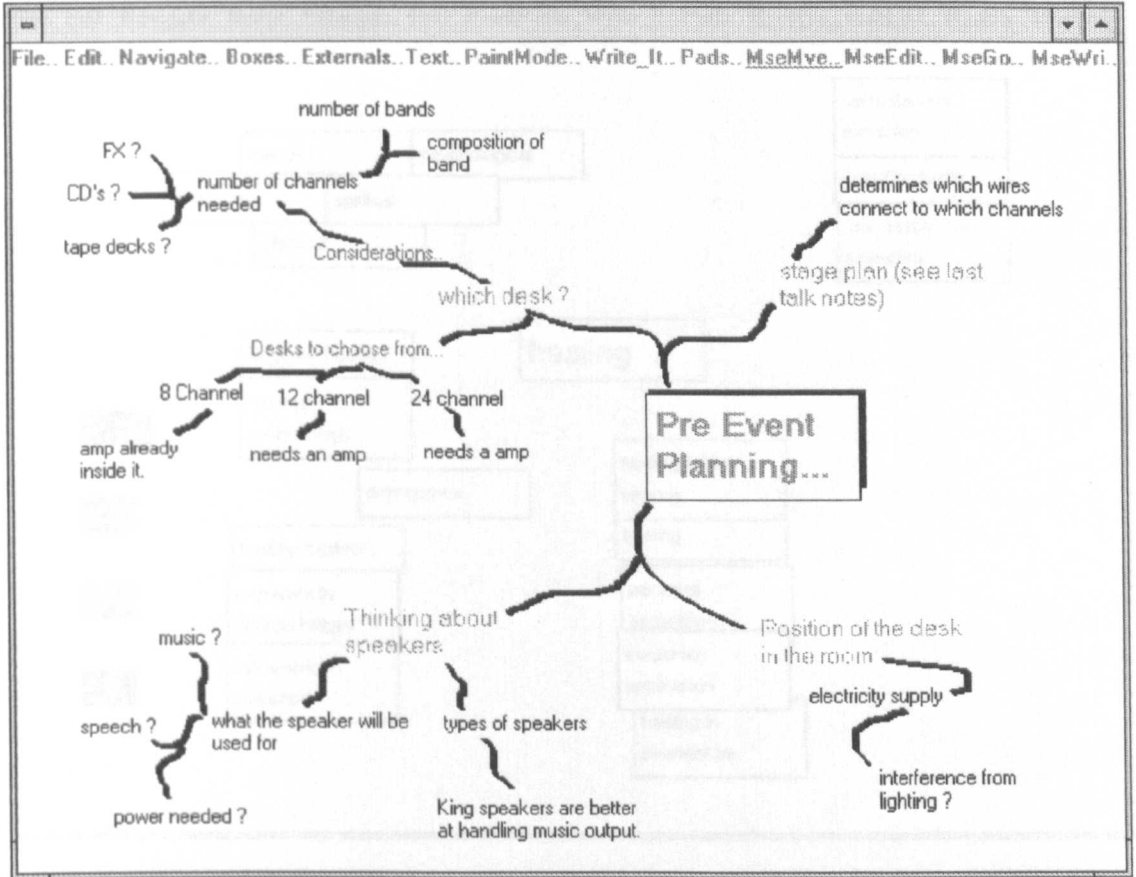


Fig A.1.4: A single map drawn by one of the centre's members - User ZC

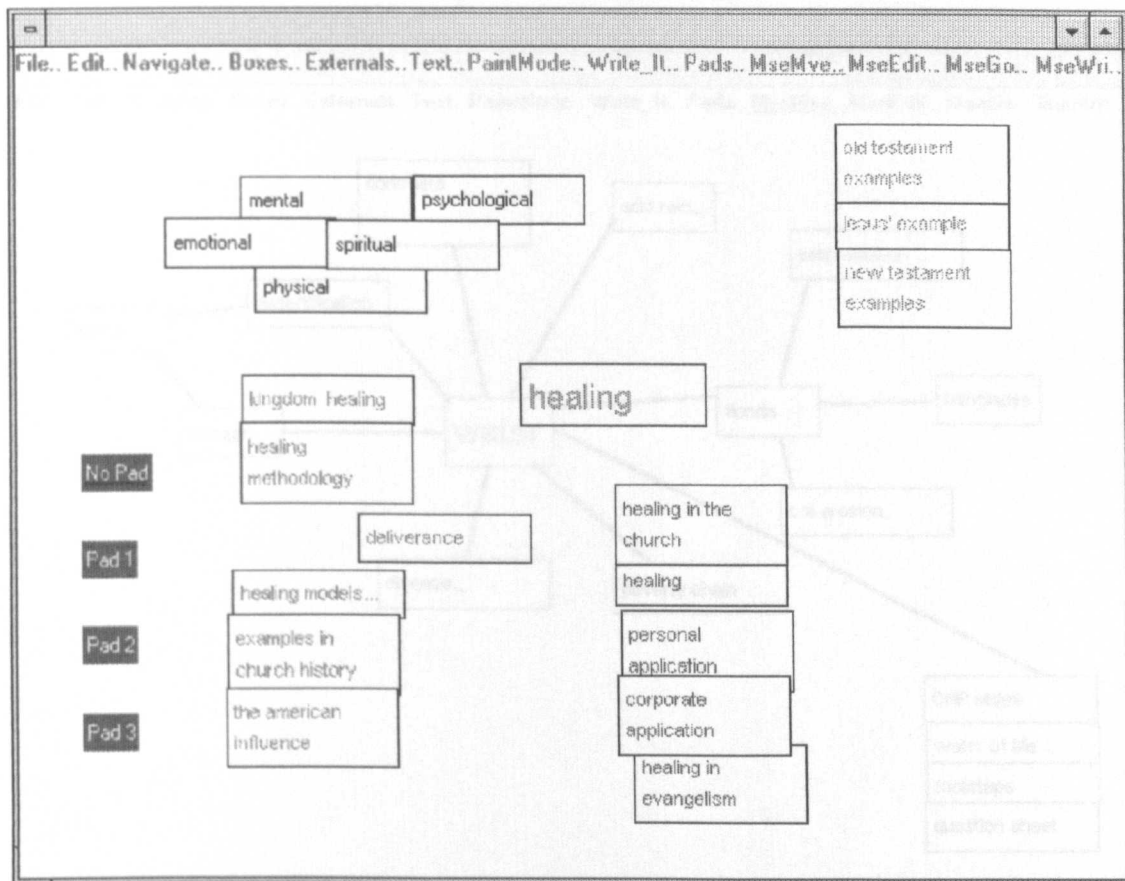


Fig A.1.5: The top-level map in a set drawn by User C relating to third-world issues

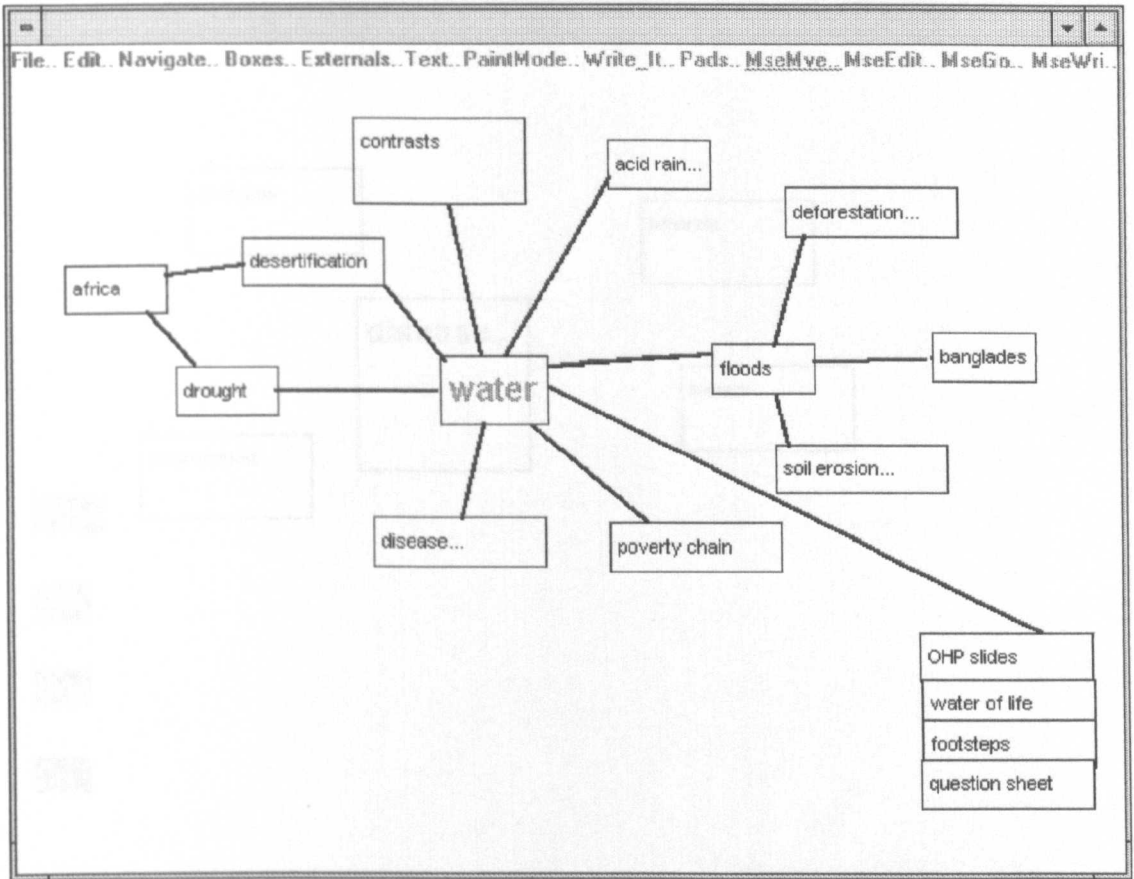


Fig A.1.6: A sub-map in a set drawn by User C relating to third-world issues

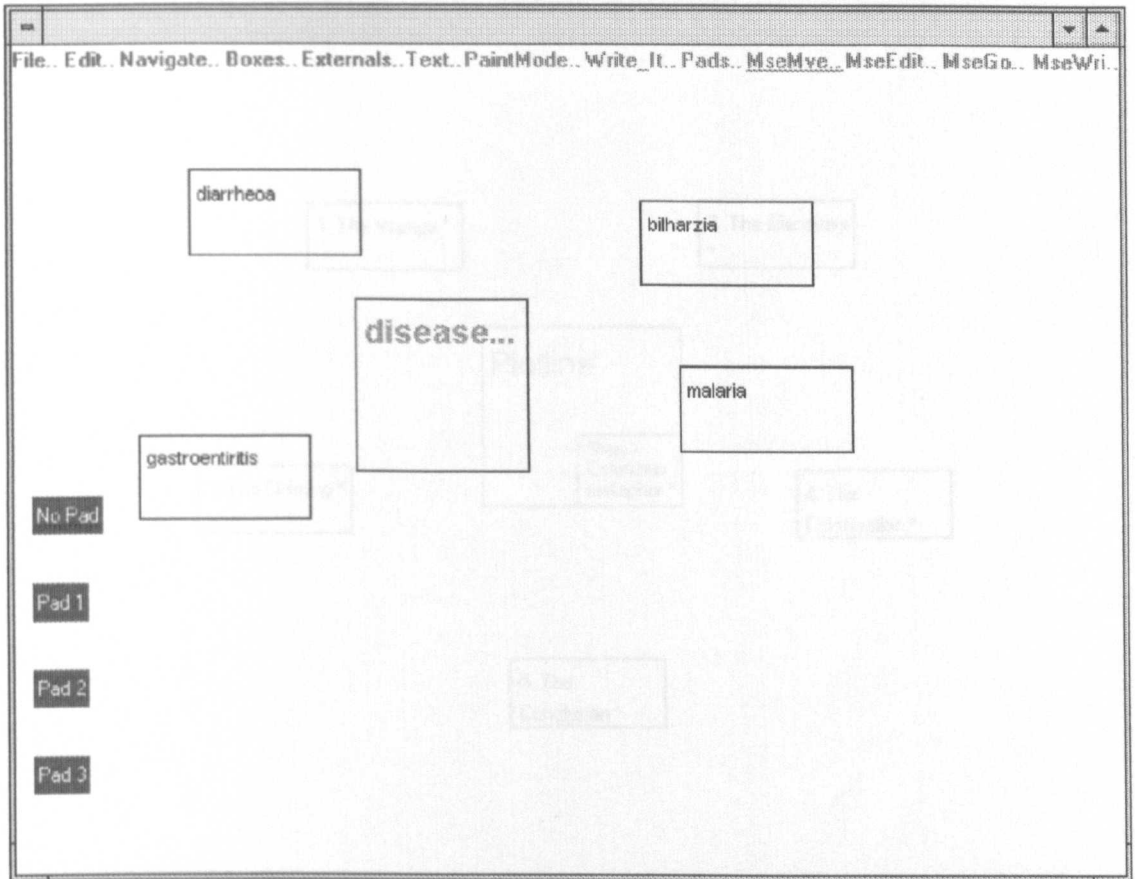


Fig A.1.7: The top-level map in a set drawn by User F as a plot line for a short story

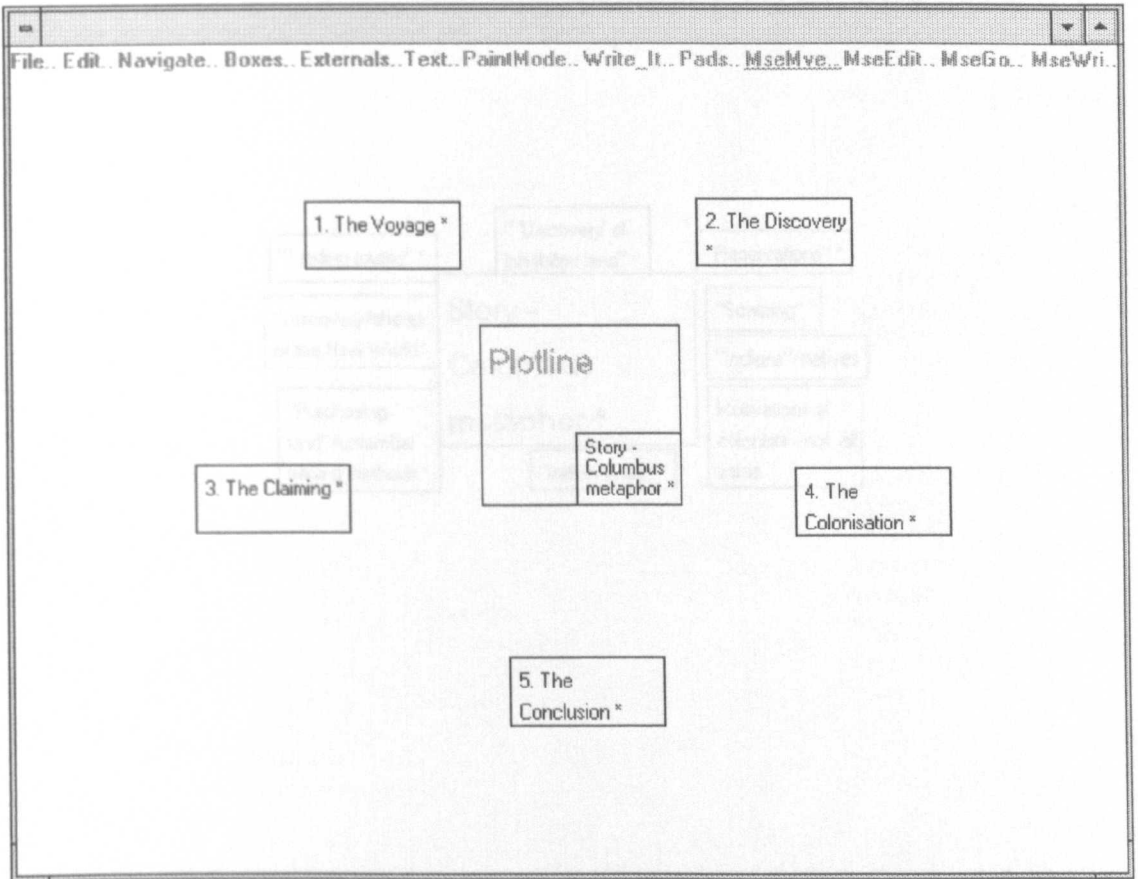


Fig A.1.8: A sub-map in a set drawn by User F as a plot line for a short story

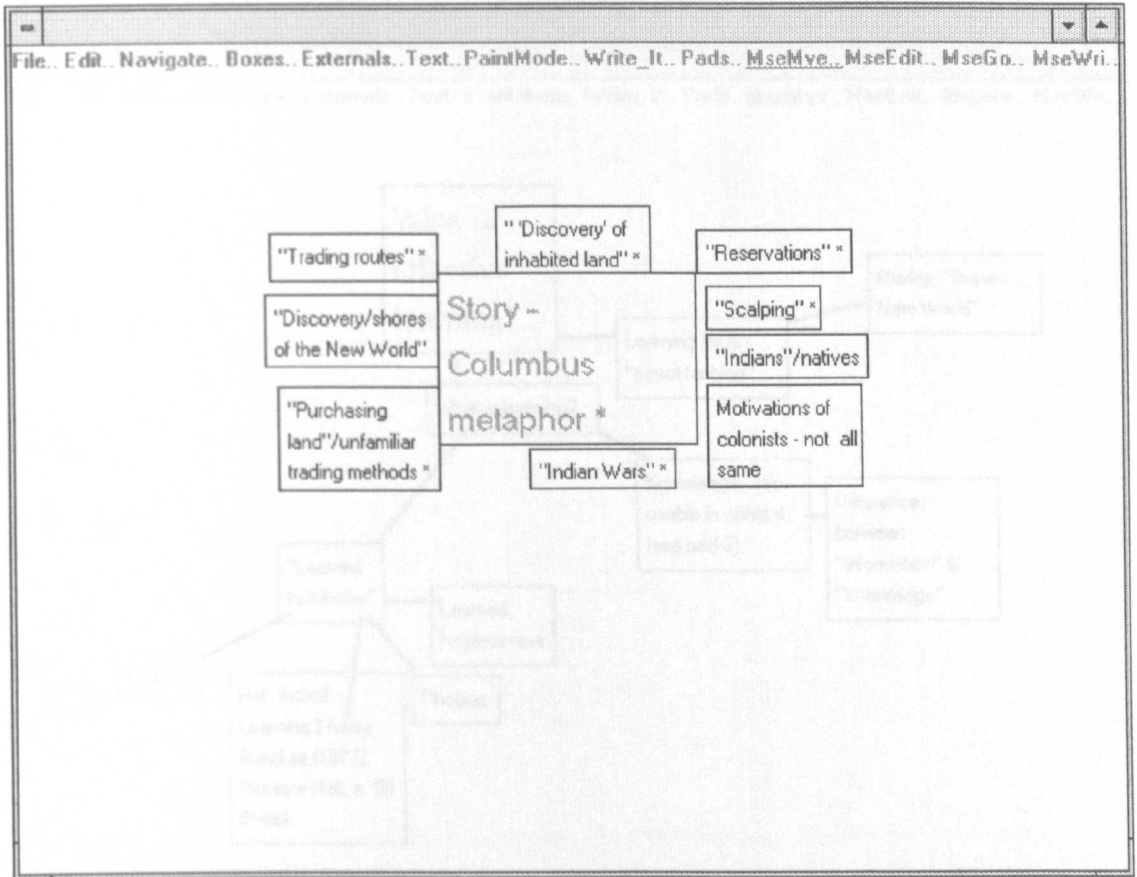




Fig A.1.9: The top-level map in a set drawn by User F to plan a mini-thesis

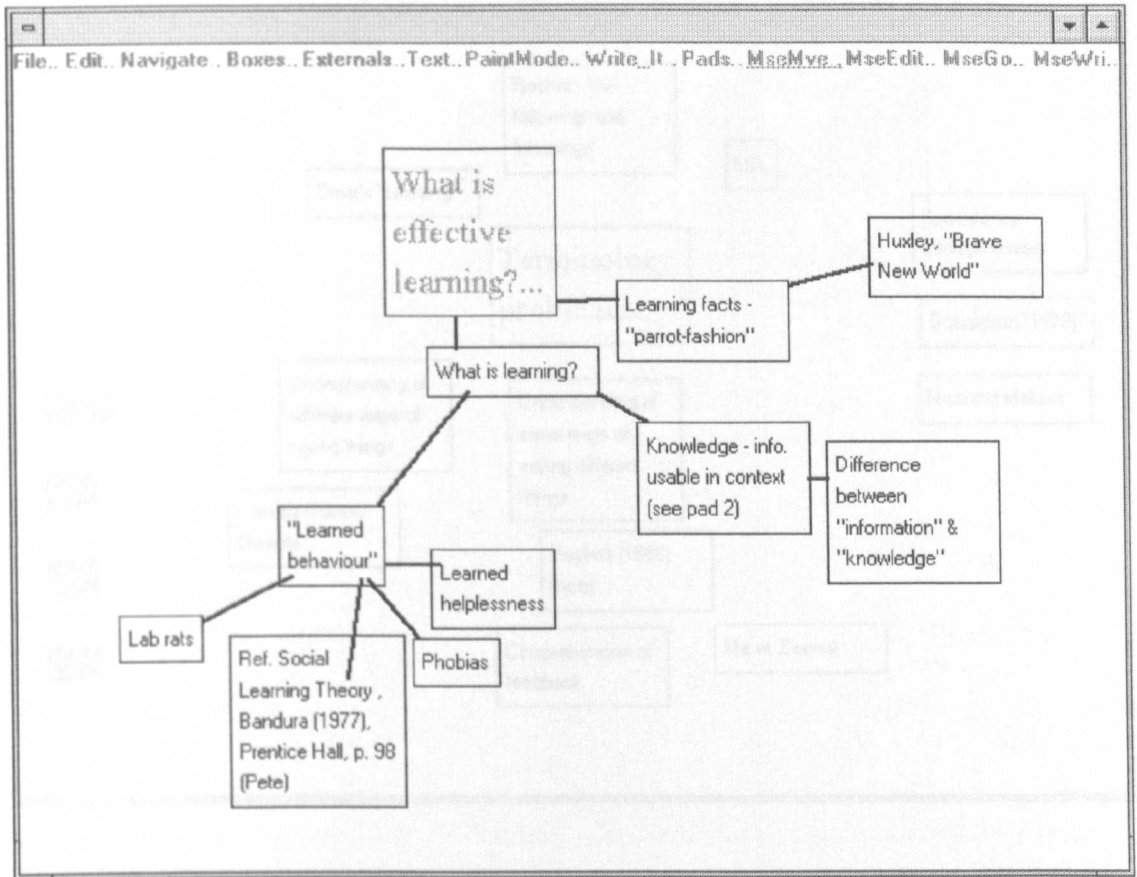


Fig A.1.10: A sub-map in a set drawn by User F to plan a mini-thesis

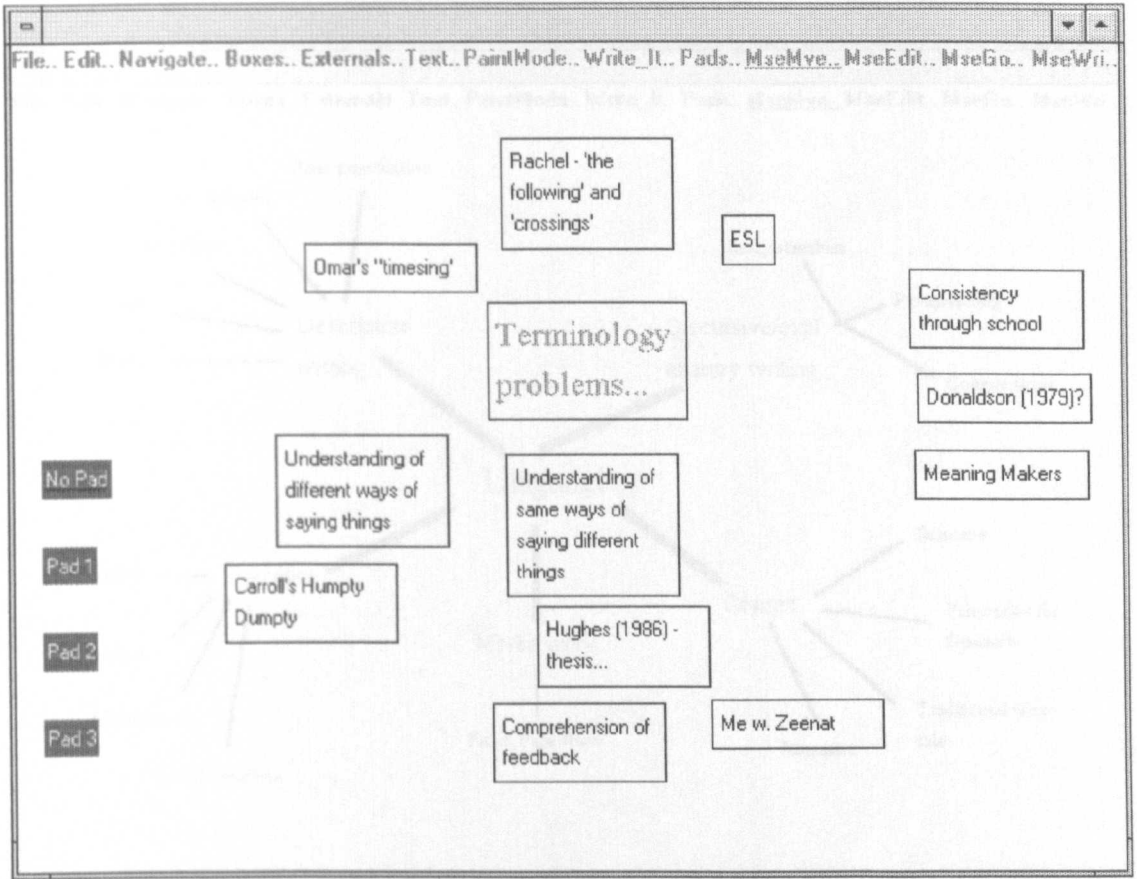


Fig A.1.11: A single map drawn as one of a set by English teacher - User P

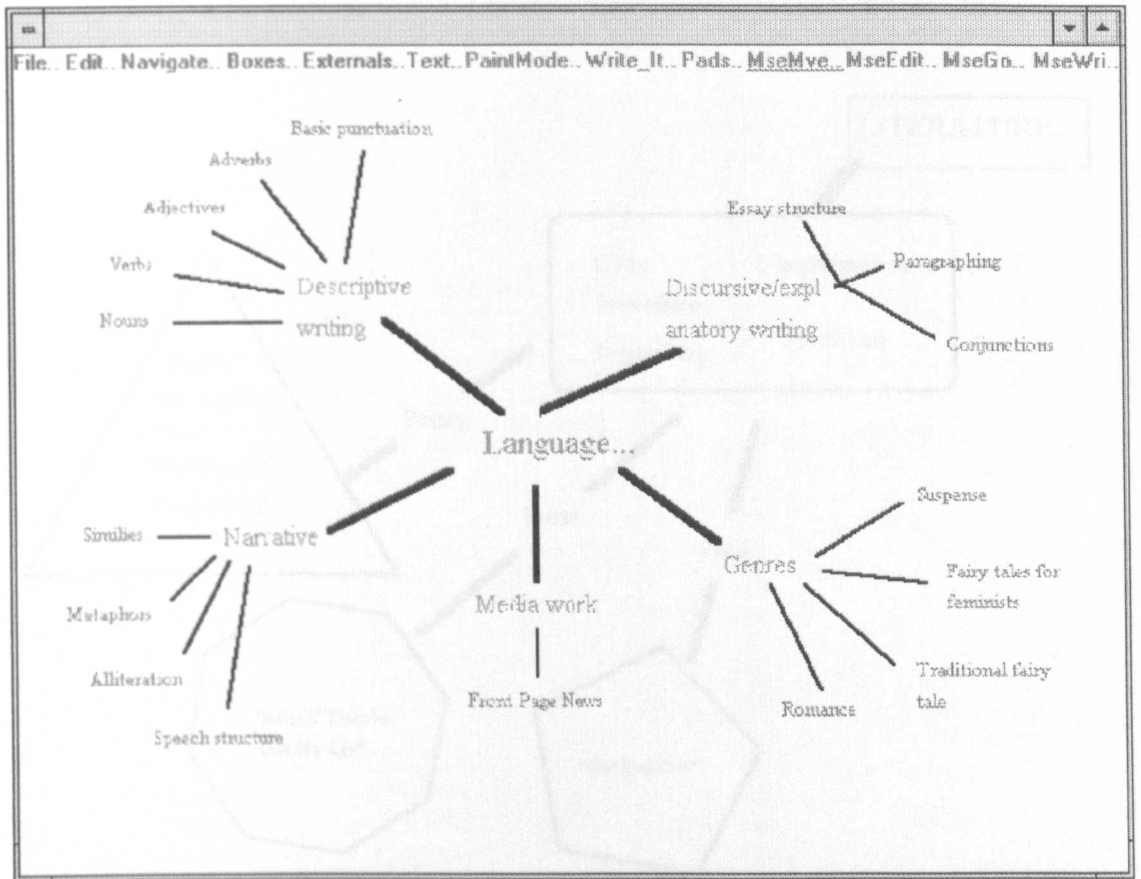


Fig A.1.12: A single map drawn as one of a set by English teacher - User P

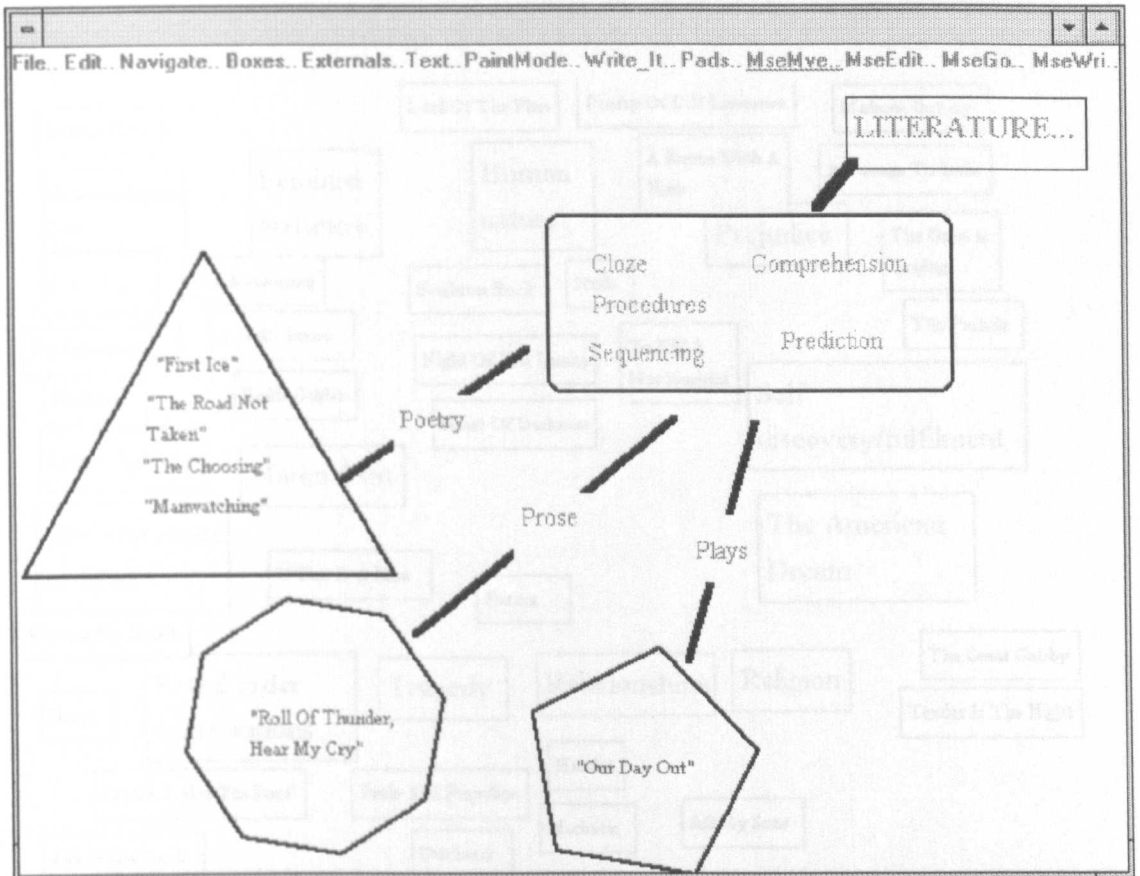


Fig A.1.13: A single map drawn as one of a set by English teacher - User P

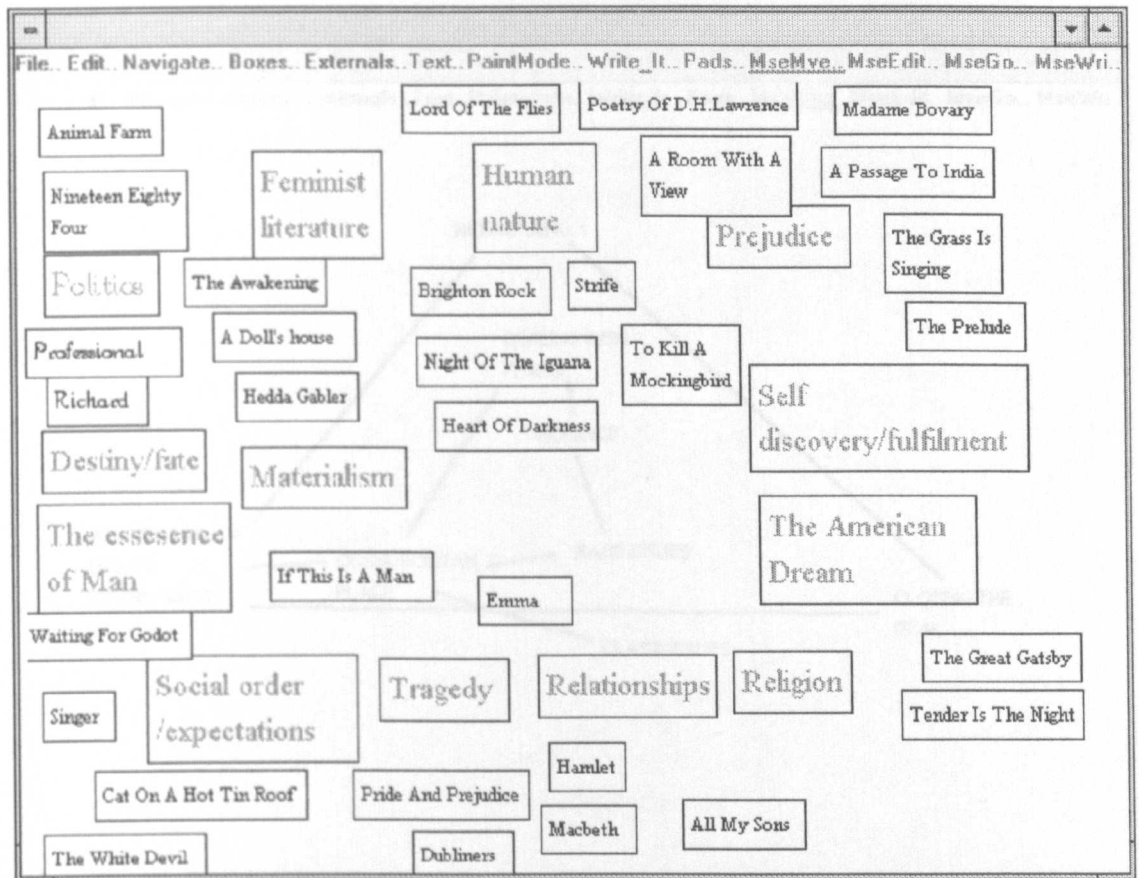


Fig A.1.14: A single map drawn to prepare a sermon by User U

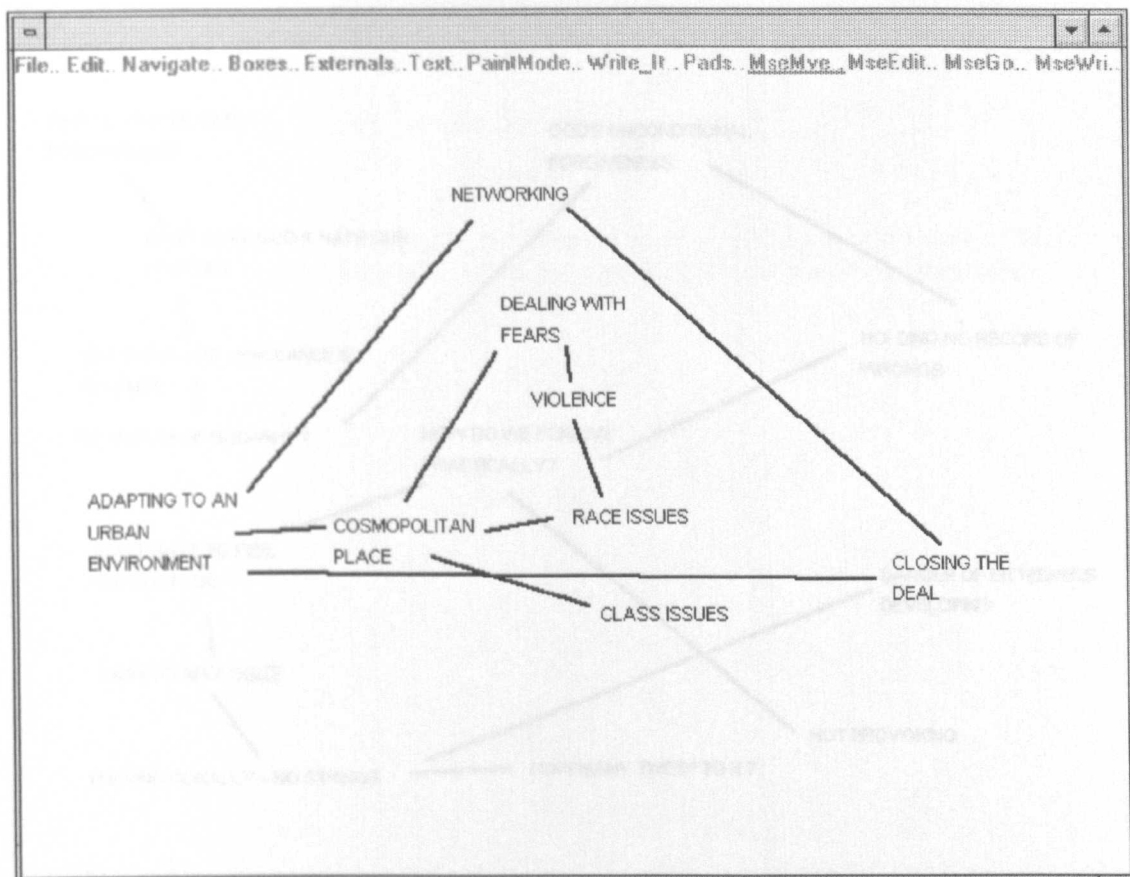
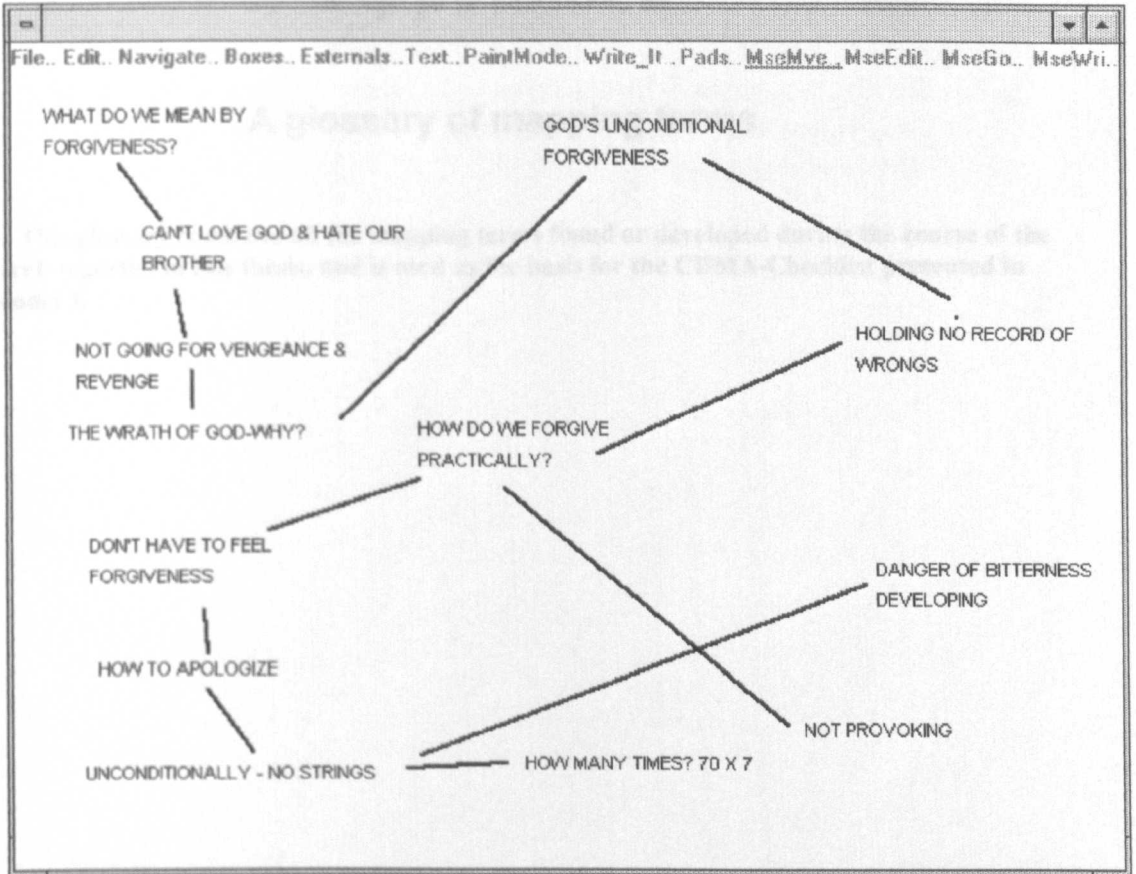


Fig A.1.15: Another single map drawn to prepare a sermon by User U



# **Appendix 2**

## **A glossary of mapping terms**

**Note: This glossary combines all the mapping terms found or developed during the course of the research reported in this thesis, and is used as the basis for the CBMA-Checklist presented in Appendix 3.**



## A.2 Introduction

This appendix draws on the discussion of the mapping process as presented in chapter two, and the discussion of the facilities to be found in computer-based mapping applications presented in chapters three and seven. It uses these discussions as the base for a set of tables (see **Fig A.2.1 - Fig A.2.7**), in which the different elements of the mapping process and the different facilities which may be found in mapping applications are given names and defined. In addition, there is a table which expands the suggestion that mapping applications might be used to support creative thinking, by listing some of the creative thinking techniques currently used in business and education, along with a number of the techniques proposed by Edward DeBono (see **Fig A.2.8**)

**Fig A.2.1: A glossary of terms which may be used to describe computer-based mapping applications**

<b>Term</b>	<b>Explanation of term</b>
Annotated links	...refers to the ability to type text onto a link.
Arrow links	...refers to the facility to draw links with arrowheads on them. If the link can be moved, it is described as <b>dynamic</b> . If the link cannot be moved, then it is referred to as <b>static</b> .
Auto-place Buzan links	...refer to the program's ability to automatically display a Buzan style link in an appropriate location. (cf. InfoMap / MindMap Plus).
AutoWrite	...refers to the facility by which a mapper can list the ideas on a given map or text pad and with a single mouse click copy those ideas to any other map or text pad.
Bit-mapped links	...refers to the facility to draw links using bit-mapped paint tools.
Bit-mapped output	...refers to the facility to output a map in a bit-mapped format
Context-sensitive pop-up menus	...refers to the facility to activate a context-sensitive pop-up menu, to reduce the distance that the mouse has to travel to access commonly used menu options.
Custom zoom	...refers to an ability to customise the amount of zoom used when viewing a map surface.
Easy input	...refers to the ability to input ideas with a single mouse click or key stroke.
Electronic report	...refers to the facility to output a report relating to the contents of the map file in an electronic format.
Expand function	...refers to a facility which enables a mapper to capture a single idea on one map and make that idea the central idea on a new map.
Export text	...refers to any facility which enables the mapper to collate ideas from one or maps in the form of a list which can be exported to a word processor.
Extended graphics options	... refers to the inclusion of basic graphics options, such as changing the size of an ideas box, being able to select multiple boxes, and being able to cut, copy or paste boxes.
Extended text options	...refers to the inclusion of the basic text options which would be expected in a word processor. For instance: the ability to change font, colour, style and size, and the ability to cut, copy and paste text.
Grid input	...refers to the ability to create a map by typing ideas and grid co-ordinates.
High-grade printed output	...refers to the ability to print to the resolution of the printer accepting the output.
Horizontal Buzan links	...is the facility to create Buzan-style links, such as those found in InfoMap.
Ideas boxes	...refers to a text field in which the user can type an idea. Ideas boxes which can be moved are described as <b>dynamic</b> . Ideas boxes which cannot be moved are described as <b>static</b> .
Ideas pad	...refers to a facility which helps users generate ideas - for example by utilising creative thinking techniques, such as those devised by Edward DeBono.
In-place editing	...refers to the ability to edit text by clicking on the ideas boxes containing that text.
Line links	...refers to the facility to draw a line between two ideas. If the link can be moved, it is described as <b>dynamic</b> . If the link cannot be moved, then it is referred to as <b>static</b> .
Magnetic links	...is the facility for the ends of links to be attached to objects, so that when the object moves, the link moves with it.
Maximise work space	... refers to the ability to minimise the screen space taken up by toolbars and menus.

Multiple shapes	...refers to the ability to create ideas boxes in a number of different shapes.
Note pad	...refers to a text pad, which may be accessed from any map in the current file.
Notes	... refers to whether the mapper can 'hide' notes under an idea.
Notice board access	...refers to the ability of a group of people to use the application as a map-based notice board.
OLE2 compliance	...refers to the ability to embed macros written in OLE2-compliant languages such as Visual Basic.
Paragraph text	...refers to the ability of the mapping software to represent ideas which consist of more than a few words.
Printed report	...refers to the ability to generate a written report based on the ideas stored in map or text formats.
Reasoning	...refers to the ability of the mapping application to make inferences from the final map.
Record /recall	...refers to the ability to record the appearance of an ideas box or line and then to apply that appearance to other boxes or lines.
Simple zoom	...refers to whether the mapper can zoom out to gain an overview of their map, when working in a virtual work area.
Spell checker	...refers to the ability to spell-check map-based text.
Standard Buzan links	...refers to the facility to create Buzan style links, such as those found in MindMap Plus.
Style sheets	...refers to the provision of style sheets to reduce the number of menu options which have to be accessed, in order to apply a particular style to text or ideas boxes.
Template support	...refers to the provision of graphical templates, which a mapper can use to focus their thinking.
Vectored output	...refers to the ability to output maps in vectored format, such as Window's Meta File.
Virtual work area	...refers to a work area which is larger than the size of the screen.

**Fig A.2.2: A glossary of terms devised by Smee (1994) relating to mapping goals**

Mapping goals	Mappers' motivations for drawing maps
Descriptive goals	...refer to the desire to model a subject domain in a precise and unambiguous manner - for example, to lead an engineer through the process of repairing some complex machinery.
Feedback goals	...refer to the desire to investigate a student's level of understanding - for example, to ascertain whether someone has understood what they have been taught.
Knowledge goals	...refer to the desire to integrate ideas from a number of sources - for example to draw together notes from a number of lectures.
Overview goals	...refer to the desire to communicate an overview - for example, to provide a map as a summary of a presentation.
Preparation goals	...refer to the desire to clarify and edit an outline for a written or oral presentation.
Problem goals	...refer to the desire to model a problem - for example, to explore the issues which might arise in a merger between two companies.
Recall goals	...refer to the desire to imprint information into memory and provide a visual stimulus to aid recall of that information - for example, constructing a map can be an effective way in which to prepare for an exam.
Solution goals	...refer to the desire to model a solution and the possible implications of that solution - for example, to model what the effect of raising interest rates might be upon the economy.
Warm-up goals	...refer to the desire to explore how much students already know about a subject which they are about to be taught.

**Fig A.2.3: A glossary of terms  
devised by Smee (1994) relating to mapping context**

<b>Mapping context</b>	<b>The context within which work takes place</b>
Solo context	...refer to mapping goals which one person works to accomplish.
Small-group context	...refer to mapping goals which a small group work to accomplish.
Large-group context	...refer to mapping goals which a large group work to accomplish.
Real-time context	...refer to group mapping goals upon which group members work simultaneously.
Asynchronous context	...refer to mapping goals upon which group members work at different times.
Distributed context	...refer to mapping goals upon which group members distributed in different geographical regions work.

Fig A.2.4: A glossary of terms devised by Smee (1994) relating to map designs

<p><b>Map designs</b></p>	<p>The different classifications devised in order to <i>compare</i> the design of concept maps with alternative map designs</p>
<p><b>Formal maps</b> <i>(Maps whose design is significantly more complex than that of a concept map)</i></p>	<p>Formal maps model a subject domain with 'dictionary-like' accuracy. Formal designs are the pictorial equivalent to formal logic and therefore require ideas and relationships to be represented more explicitly and more accurately, than required when a mapper is constructing a concept map. Examples of formal maps are flow diagrams and semantic nets. The main difference between formal maps and concept maps is that formal maps take much longer to construct because of the level of detail and accuracy required.</p>
<p><b>Informal maps</b> <i>(Maps whose design is of 'equivalent' complexity to that of a concept map)</i></p>	<p>Informal maps are named thus because aspects of the subject domain being modelled are represented implicitly - the map being used as an aide-memoir, rather than a detailed description. Concept maps are the simplest kind of informal map. Other forms of informal map include causal maps and Buzan maps. It is the simple nature of the concept maps, which underlies the decision of this thesis to propose that a concept map is the best trade-off between explicitly modelling a subject and the need to minimise the effort required in the modelling process.</p>
<p><b>Spatial maps</b> <i>(Maps whose design is less complex than that of a concept map)</i></p>	<p>A spatial map is one in which relationships between ideas are represented by clustering ideas, so that those ideas which are related are placed physically near to one another on the work surface. Spatial mapping protocols, such as concept sorting, are foundational in the construction of other map designs. Providing work is conducted in a dynamic medium, the easiest way in which to produce a formal or an informal map is to first construct a spatial map. Having constructed a spatial map, the mapper can then edit that map into an appropriate form. It is the foundational nature of spatial maps which underlies the decision of this thesis to propose that concept maps be developed using the following two-stage process: (1) use the <i>process</i> of concept sorting to <i>produce</i> a concept sort, (2) edit the concept sort into the form of a concept map.</p>
<p><b>Template maps</b> <i>(Maps whose design is significantly more constrained than that of a concept map)</i></p>	<p>Template designs may be split into two categories - <b>simple</b> and <b>complex</b>. A simple template map provides the user with blank spaces, which prompt the mapper to think of ideas to write in those spaces. Complex template maps, in addition to prompting the mapper with blank spaces, also prompt the mapper to use a structured mapping protocol. An example of a complex template map is Soft System Methodology. Examples of simple template maps are causal chains and force field diagrams.</p>

**Fig A.2.5: A glossary of terms devised by Smee (1994) relating to mapping media**

<b>Mapping media</b>	<b>The tools the mapper uses to enable the mapping process</b>
<b>Computer-based</b>	...refers to the use of a computer in order to facilitate the process of generating and sorting ideas.
<b>Move &amp; stick</b>	...refers to the traditional concept-sorting protocol in which ideas are written on pieces of paper (or plastic) and then sorted on a table top (or magnetic board).
<b>Write &amp; wipe</b>	...refers the use of a blackboard or whiteboard, onto which the mapper draws his or her map.
<b>Write-once media</b>	...refers to the use of paper, onto which the mapper draws his or her map.

**Fig A.2.6: A glossary of terms devised by Smee (1994) relating to categories of mapping media**

<b>Kind of media</b>	<b>Categories into which different mapping media may be placed</b>
<b>Dynamic media</b>	...refers to media where it is relatively easy to make changes to a map.
<b>Static media</b>	...refers to media in which it is difficult to make changes to a map.

**Fig A.2.7: A glossary of terms taken from the literature relating to commonly used template designs**

Term	Explanation of term
Assessment continua	...show how ideas relate to one another in terms of descriptions which are polar opposites. (See Clarke 1991)
Causal chains	...help focus people on backward and forward reasoning by getting them to describe a chain of events. (See Clarke 1991)
Crosswords	...help people think about what might be associated with a central concept by surrounding the central concept with a number of blank spaces, which the mapper can fill in. (See Pereiche 1990).
Force-field diagrams and weighing arguments	...help people focus on the fact that there may be positive and negative aspects to a decision. This focus helps people to work to increase the positives and disempower the negatives. (See Clarke 1991)
Relational glossary	...is a way in which to represent concepts through their definitional relationship with other concepts. It forces consistency, connectivity, and loop closure. (See Zimmer 1984).
Soft System Methodology	Soft System Methodology recognises that many decisions are 'political' in nature and provides a rigorous technique to navigate the decision maker through the process of modelling opinions (see Checkland 1981 and 1990).
Story lines	...help someone to prepare all the elements of a story before beginning to write that story. (See Clarke 1991)
Tables and graphs	...can be used to visually organise ideas, so that associations and relationships are made more explicit. (See Clarke 1991)
Time lines	...focus the mapper on events in time. (See Clarke 1991)
Vee-diagrams	...can be used to show data, beliefs and conclusions, so that it becomes easier to see how a researcher has derived their conclusions. (See Novak 1990).
Venn-diagrams	...also known as Concept Dictionaries (McGraw/Harbison-Briggs 1989) and Concept Circles (Wandersee in Novak 1987) are a pictorial way in which to represent how ideas fall into different categories, and how those categories relate to one another.
Webb diagrams	...(also known as Spider Diagrams) have a central concept surrounded by a number of blank spaces into which mappers write any ideas which they associate with the central concept. (See Clarke 1991)



**Fig A.2.8 A glossary of terms taken from DeBono (1990)**

Term	Explanation of term
Agreement, disagreement, interest (ADI)	...directs the thinker to list all the points of agreement, disagreement, and neutrality in a dispute.
Alternatives, possibilities, choices (APC)	...directs the thinker to list the evidence and explore alternative meanings.
Brainstorming (BS)	...directs the thinker to list all the associations they have with the subject of the brainstorming session.
Consequences & sequel (C&S)	...directs the thinker to assess the possible consequences of a course of action at different points of time in the future.
Consider all factors (CAF)	...directs the thinker to list all the factors which must be taken into account before making a particular decision.
Examine both sides (EBS)	...directs the thinker to examine an opponent's point of view by asking the thinker to argue for that point of view.
Goal setting (GS)	...directs the thinker towards setting a single goal and then sub-dividing that goal into a number of more manageable sub-goals.
inFormation In inFormation Out (FiFo)	...directs the thinker to list all the information to hand, and all the information which is required, before it will be possible to make a particular decision.
One plus one equals three (1+1=3)	...directs the thinker to take two existing words and to generate a third by finding one way in which the original words are similar.
Other people's views (OPV)	...directs the thinker towards how other people might react towards a proposed course of action.
Positive, minus, interesting (PMI)	...directs the thinker to think of all the positive, negative and neutral consequences which will accrue as the result of a proposed course of action.
Possibilities (PO)	...directs the thinker to think up improbable and fantastic solutions, and relate those solutions to a difficult problem, in order to bring in fresh insight.
Random generator (RG)	...directs the thinker to find links between a problem and a word taken at random from a dictionary, in order to bring in fresh insight.
Value laden words (VLW)	...directs the thinker towards rhetoric and emotionally laden words, which add hidden meaning to a text.

**Fig A.2.9: A glossary of terms relating to the ways in which people can interact with mapping media**

Term	Explanation of term
Disclosure protocol	...refers to the process of creating a set of mental associations, and then externalising those associations before they are lost from working memory.
Organic protocol	...refers to the process of generating and sorting ideas in a cyclical process. The mapper uses mapping as a form of 'mental scaffolding'.
Step protocol	...refers to the process of downloading ideas from an external source (such as a database) before sorting those ideas in an organic fashion.

# **Appendix 3**

## **Pilot studies**

**This appendix presents an overview of two pilot studies conducted at the Open University. The aim of both studies was to find out what people know about visually generating and sorting ideas, what kinds of mapping goals they engage in, and what kinds of map designs and mapping media they use to achieve those goals.**

# A.3.1 Pilot study 1

## A.3.1.1 Introduction

Pilot study 1 sought to investigate two questions raised as a result of the interviews with KwikSort users. Those two questions were:

- What proportion of mappers utilise disclosure protocol? and,
- Would mappers benefit from tuition which helps them to use mapping more effectively?

## A.3.1.2 Method

To address each of the issues raised above a questionnaire was devised, based on the experience gained from a literature survey and from experience gained during interviews with KwikSort users. This questionnaire was then distributed to 100 staff and students in the Department of Education and the Institute of Educational Technology at the Open University. Respondents were asked to return the questionnaire using the University's internal post.

## A.3.1.3 Results of pilot study 1

38 of the 100 people to whom questionnaires were sent responded. It was found that 27 of the 38 respondents used some kind of map-like diagram to generate, sort and/or present their ideas. Of the 27 mappers, it was found that 20 reported utilising the organic protocol and 7 reported utilising disclosure protocol.

With respect to how much the mappers know about different mapping techniques, the following findings were made:

- In terms of map design - it was found that of the 38 respondents: 8 did not know of any map designs, 11 knew one or two map designs, 12 knew three or four map designs, and only 5 knew more than four map designs. To be precise: 26 knew how to draw flow diagrams, 19 knew how to draw concept maps, 21 knew how to draw Venn diagrams and 7 knew how to draw force-field diagrams.
- In terms of mapping goals, of the 27 mappers: 3 were engaged in warm-up goals, 20 were engaged in knowledge goals, 7 were engaged in revision goals, 8 used feedback mapping, 10 used problem mapping, 13 used solution mapping, 17 were engaged in overview goals, and 14 were engaged in descriptive goals.
- In terms of mapping media - it was found that of the 27 mappers, 11 were using inappropriate media. Usually this meant that mappers who wanted to map organically were constructing maps using relatively static media. Of the 11 mappers using inappropriate media, it was found that 2 agreed with a statement that 'mapping took too much effort to be worth while' while 4 disagreed with such a statement. In contrast, of the 16 mappers who used appropriate mapping media, only 2 agreed with the statement that mapping took too much effort and 9 disagreed.

### A.3.1.4 Problems with pilot study 1

When interpreting the responses to this pilot study, it was found that there were a number of problems with the way in which the questions had been asked and the way the questionnaire had been structured. These problems were:

- With respect to investigating people's understanding of mapping and mapping techniques, it was realised that several important techniques had been omitted, such as Thinking With Hexagons and Concept Sorting. It was also realised that many people were confused by the phrasing of Question One, which asked people how many mapping techniques they had been taught, rather than how many mapping techniques they knew well enough to use. The confusion occurred because many respondents had taught themselves how to map.
- In terms of finding out which mapping goals people might pursue, it became evident that the phrasing of Question 4 was inappropriate. This question asked what techniques mappers *had* used in the last three years, rather than asking what techniques they would use *given the appropriate circumstances*.
- When it came to enquiring how many people use inappropriate mapping media, it would have made sense to ask about disclosure mapping, at the same time as asking about other mapping media.
- In terms of perceived effort, it was found that many parts of Question Six were confusing. The answers provided by respondents suggested to the author that the investigation into perceived effort should have used more explicitly phrased questions.
- In terms of enquiring about group mapping, the questionnaire was devised before it was realised how important group mapping might be, and so did not explicitly ask what group mapping goals respondents might want to complete.
- The structure of the questionnaire may have dissuaded non-mappers from sending back their forms. The wording of the form may have implied that the study was not interested in the feelings of those who did not use mapping. To counter this, any new questionnaire would need to have a statement to the effect that the study is seeking to determine BOTH how many people know about mind mapping AND how many mapping techniques people use to help them in their work.
- Since many of the respondents came from a computer department, most were likely to know about flow diagrams, and consequently would be more knowledgeable about displaying knowledge in a graphical way. It might have been better if the respondents had come from a number of different departments and disciplines.
- Unfortunately, the questionnaire was devised just before it was realised the extent to which groups might want to achieve group mapping goals, so insufficient questions were asked to find out how many mappers were interested in working collaboratively.

### **A.3.1.5 Conclusions from pilot study 1**

The results from pilot study 1 indicate:

- About a quarter of mappers report using the disclosure mapping protocol.
- Nearly half of the respondents use inappropriate mapping media.
- On average mappers know only four of the ten mapping goals.
- Most mappers know four (or less) of the twelve map designs.

From the results it can be concluded that: a significant number of mappers use the disclosure protocol, who need to be taken into account when designing mapping software and selecting appropriate hardware, and that many mappers would benefit from being taught how to use mapping more effectively. However, the validity of these conclusions has to be held in tension with the numerous problems found with the questionnaire.

## **A.3.2 Pilot study 2**

### **A.3.2.1 Introduction**

With the results of pilot study 1 in hand, a second questionnaire was written and distributed to 220 staff and students at the Open University. The aims of this second questionnaire were to investigate three research questions, arising from a literature review and from interviews with KwikSort users. These three research questions were:

- What proportion of people report preferring the disclosure protocol?
- What proportion of people would like to use mapping in a collaborative setting?
- Would mappers benefit from tuition which teaches them how to make better use of mapping?

The answers to these questions are important because they contribute to an understanding of how many people might find computer-based mapping useful, and what kinds of facilities computer-based mapping applications should provide.

### **A.3.2.2 Method**

To address the research questions stated above, 220 questionnaires were distributed by hand, by posting into staff pigeon holes at the Open University in Milton Keynes. Of these 220 questionnaires, 150 were distributed in the Business School and 70 were distributed in the School of Health and Community Education. Those receiving the questionnaire were asked to answer the questionnaire and return it by placing it in the internal post.

### **A.3.2.3 Respondents**

The respondents for this study were staff and researchers from the Business School and School of Health and Community Education at the Open University in Milton Keynes. Of the 220 questionnaires distributed, a third (72) were returned. Of these responses 47 were from the Business School, 16 were from the School of Health and Community Education and 9 were unattributed. In addition, it should be noted, that of the 72 who responded, 55 knew at least one mapping technique and all reported being involved in activities in which concept mapping might be utilised.

### **A.3.2.4 Results of pilot study 2**

With respect to the disclosure protocol, respondents were asked whether they tended to prepare maps in their 'mind's eye' before drawing them, or whether they tended to draw their maps by adding and sorting a few ideas at a time. In response to this question, of the 55 respondents who said that they knew at least one mapping technique, 5 reported mapping in a way which might be described as the disclosure protocol. With respect to mapping goals, respondents were asked to tick the mapping goals which they would feel comfortable using, should the appropriate circumstances arise. In response, of the 55 people who knew how to use at least one mapping technique, 48 said they would consider using maps in both solo and collaborative settings, should an appropriate opportunity arise. With respect to questions probing mappers' knowledge of mapping techniques, the following findings were made. In terms of map designs (/techniques) - it was found that on average mappers know how to use 4 map designs (/techniques) - the most widely

known designs (/techniques) being flow diagrams and force-field diagrams, the least known designs (/techniques) being Vee diagrams, concept sorting and Thinking With Hexagons. (Less than 5 mappers knew about concept sorting or Thinking With Hexagons). In terms of mapping goals - of the nine solo goals listed, the most likely goals to be pursued (given appropriate circumstances) were: knowledge goals, solution goals, preparation goals and description goals; of the nine group goals listed, the most likely goals to be pursued (given appropriate circumstances) were: problem goals, solution goals and preparation goals. (Over 50% of mappers ticked each of these options). In terms of mapping media, it was found that of the 55 people who knew at least one mapping technique, only 12 could be identified as using an *appropriate* mapping medium. With respect to whether any of the 55 mappers would make more use of mapping if it were easier to draw maps, and if a way could be found to more easily draw well-presented maps - it was found that: 16 *would* use mapping more often if a way could be found to make mapping easier; 17 *would* use mapping more often if a way could be found to make maps more presentable; 7 *would not* be interested in using mapping more often, even if a way were found to make maps easier to draw or more presentable; and 24 *were unsure* how they would react if shown a way to draw maps more easily, and were unsure how they would react if shown a way to make maps more presentable. In short, a summary of results would read as follows:

- About one in ten mappers reported using the disclosure protocol.
- About nine in ten mappers would use mapping in a group context, given appropriate circumstances.
- Few mappers knew how to use dynamic mapping techniques, such as concept sorting or Thinking With Hexagons

### **A.3.2.5 Problems with pilot study 2**

The main problem with pilot study 2 was that a questionnaire approach makes it difficult to gain a true insight into how people are using mapping to support their day to day work, and how providing people with new mapping strategies might affect their use of mapping as a cognitive tool or as a means of interpersonal communication. In addition, a disappointment with the study was that more people did not respond. Although the return rate was not unduly low, the author had hoped for a higher return rate, so that it might be possible to gauge the proportion of people who knew nothing about mapping. Perhaps a study which uses personal canvassing of respondents may be a better way to get this information. The problem with questionnaires filled out by respondents in their own time is that if the respondent is not interested in the subject matter of the questionnaire, they may be less likely to return it. Thus, those who return a questionnaire may not be representative of the group to whom the questionnaire was sent.

### **A.3.2.6 Discussion of pilot study 2**

In chapter seven of this thesis, it is suggested that those who would get most benefit from computer-based mapping would be those employing the organic protocol. The data from this pilot study show that most mappers usually use an organic protocol and would therefore find computer-based mapping applications helpful. With regard to group work, in chapter two it was suggested that mapping in a group context (in which the group consisted of more than a few people) might necessitate the development of new hardware, and that developers of mapping software need to consider how to adapt their software to



make it more 'group friendly'. The data collected here underline that suggestion. With so many people expressing an interest in group mapping, the needs of those engaged in group mapping certainly need to be examined further. Finally, with regard to tuition, the data would indicate that there is a low level of knowledge relating to the ways mapping can be used and the ways in which maps can be drawn. In particular, it is disappointing that so few people know about simple, yet powerful, dynamic mapping techniques such as Thinking With Hexagons and concept sorting. It is therefore recommended that most mappers be provided with some form of tutorial, which gives them more information about concept mapping techniques, and how to apply them.

### **A.3.2.7 Conclusions from pilot study 2**

It is the conclusion of this study that computer-based mapping is useful for most mappers, because most mappers map organically. It is also the conclusion of this study that mapping applications need to have facilities which enable them to be used in group contexts, and which enable the mapper to make a more informed choice about the mapping techniques available to them.

# Appendix 4

## The original CBMA-Checklist

The following pages present a checklist completed by the author and used as the basis for the design of BrainBox. It should be noted that this represents an earlier version of the CBMA-Checklist than that presented in Appendix 5. It should also be noted that a typeface simulating handwriting has been used to emphasise the data entries.

Note that the initial checklist presented uses terminology slightly different from the final checklist, because a number of changes were made to the terminology in order to make the glossary of terms easier to understand.

# CBMA-Checklist

**A checklist for use by those designing or reviewing  
computer-based mapping applications  
with respect to a pre-defined set of mapping needs**

Name of application: *Brainbox*

*Section 1: Identifying the uses to which the application will be put*

**Identify the mapping goals the application should be able to support:**

Warm-up mapping	.....	<b>yes</b> - no
Knowledge mapping	.....	<b>yes</b> - no
Feedback mapping	.....	<b>yes</b> - no
Recall mapping	.....	<b>yes</b> - no
Problem mapping	.....	<b>yes</b> - no
Solution mapping	.....	<b>yes</b> - no
Preparation mapping	.....	<b>yes</b> - no
Overview mapping	.....	<b>yes</b> - no
Descriptive mapping	.....	yes - <b>no</b>

**Note any points of interest relating to the uses to which the mapping application will be put:**

*Brainbox should support the use of thought maps as forms of mental scaffolding, enabling people to generate and collate their thoughts into some kind of meaningful whole. Basic print-out is important, but the application should emphasise map construction in terms of process, rather than product.*

**NB1: All the mapping goals except for descriptive mapping are best attained through the use of spatial maps, which are then converted into informal maps if the map is complex or is to be shown to somebody else.**  
**NB2: All the mapping goals, except for overview mapping and descriptive mapping, are more concerned with the process of map construction, than with the final product.**

*Section 2: Identifying the kinds of map designs which the application should be capable of supporting*

In the light of previous answers, identify the kinds of map designs which the mapping application should be capable of supporting:

Simple templates	.....	yes - <u>no</u>
Complex templates	.....	yes - <u>no</u>
Spatial designs	.....	<u>yes</u> - no
Informal designs	.....	<u>yes</u> - no
Formal designs	.....	yes - <u>no</u>

Note any points of interest relating to map designs:

*The aim is for Brainbox to be a simple to use, process-based mapping application based on spatial mapping, with a limited facility for converting spatial maps into informal maps. The presentational features needed to provide for the needs of template designs and formal map designs would mean re-implementing tools already available in other applications.*

.....  
.....  
.....  
.....  
.....

**N.B. The use of template designs can be useful when a suitable template exists for a well-defined task, when the mapper is inexperienced, and when the subject is complex. A template can help direct the mappers attention towards the salient aspects of the subject being mapped.**

### **Section 3: Listing the template designs which the application should support**

**If the application is to provide the user with pre-defined templates, tick the templates which are to be supported, from the list below:**

Soft System Methodology .....		yes - <b><u>no</u></b>
Assessment continua .....		yes - <b><u>no</u></b>
Causal chains .....		yes - <b><u>no</u></b>
Crossword .....		yes - <b><u>no</u></b>
Force-field diagrams .....		yes - <b><u>no</u></b>
Story lines .....		yes - <b><u>no</u></b>
Tables .....		yes - <b><u>no</u></b>
Graphs .....		yes - <b><u>no</u></b>
Time lines .....		yes - <b><u>no</u></b>
Vee diagrams .....		yes - <b><u>no</u></b>
Venn diagrams .....		yes - <b><u>no</u></b>
Other .....		yes - <b><u>no</u></b>
		(If yes, then define...)

**If the application is to enable users to produce their own templates, tick the templates which are to be supported, from the list below:**

Soft System Methodology .....		yes - <b><u>no</u></b>
Assessment continua .....		yes - <b><u>no</u></b>
Causal chains .....		yes - <b><u>no</u></b>
Crossword .....		yes - <b><u>no</u></b>
Force-field diagrams .....		yes - <b><u>no</u></b>
Story lines .....		yes - <b><u>no</u></b>
Tables .....		yes - <b><u>no</u></b>
Graphs .....		yes - <b><u>no</u></b>
Time lines .....		yes - <b><u>no</u></b>
Vee diagrams .....		yes - <b><u>no</u></b>
Venn diagrams .....		yes - <b><u>no</u></b>
Other .....		yes - <b><u>no</u></b>
		(If yes, then define...)

***N.B. Different templates have different levels of complexity and take up different amounts of space; therefore the kinds of templates implemented may affect the kinds of presentational facilities which need to be provided.***

*Section 4: Identifying the ways in which users will want to interact with the application*

Identify kinds of mapping the application should support:

Disclosure mapping	.....	yes - <b>no</b>
Organic mapping	.....	<b>yes</b> - no
Step mapping	.....	<b>yes</b> - no
Presentational mapping	.....	yes - <b>no</b>

Note any points of interest relating to kinds of mapping which the application should support:

*Brainbox should focus on supporting the majority of mappers, who want to use the process of constructing a map as a form of mental scaffolding. Other programs already exist which support the needs of presentational mappers. It would, however, be useful if Brainbox could output to more sophisticated applications, should the need arise.*

**NB1: Organic mapping requires process-based tools which allow the user to add and sort a few ideas at a time.**

**NB2: Step mapping requires process-based tools which allow a mapper to generate a large number of ideas before sorting those ideas.**

**NB3: Disclosure mapping involves the generation of a map in the mapper's mind's eye and the expression of that map before the set of associations is lost from memory.**

**NB4: Disclosure mapping is not normally utilised in a computer-based environment, because typing interferes with the mapper's flow of thought.**

**NB5: Presentational mapping requires advanced presentational tools, which enable quality maps to be distributed to others.**

*Section 5: Identifying the kinds of process-based and presentational facilities which the mapping application should provide*

With regard to previous answers, determine whether the following kinds of facilities would make the user's work easier :

- |  |  |
|--|--|
| A basic set of process-based facilities .....      | <u>yes</u> - no                              |
| An advanced set of process-based facilities .....  | <u>yes</u> - no                              |
| A basic set of presentational facilities .....     | <u>yes</u> - no                              |
| An advanced set of presentational facilities ..... | yes - <u>no</u>                              |
| Other .....  | yes - <u>no</u><br>(if yes, then explain...) |

Note any points of interest relating to the kinds of facilities the application should support:

*In order to implement the design objectives (stated earlier) the focus will be firmly on process-based facilities. The only kinds of non-presentational based tools will be a simple print facility, the capacity to draw arrows, and OLE automation, allowing BrainBox to be used as a front end for Visio.*

**NB1:** Applications supporting spatial designs, informal designs, process-based map goals, or mappers who use mapping as a form of mental scaffolding, will need to provide at least a basic number of process-based facilities and presentational facilities.

**NB2:** Applications supporting overview mapping, descriptive mapping, and formal designs may need a sophisticated set of presentational facilities, depending upon the complexity of the map design and the people to whom the map will be distributed.

**NB3:** A sophisticated set of presentational tools is useful for those who want to produce template maps for others to use.



**Section 6: Identifying the kinds of basic process-based facilities which should be provided**

Tick the following basic *process-based* facilities required in the application:

Autowrite	.....	<b>yes</b> - no
Easy input	.....	<b>yes</b> - no
Expand facility	.....	<b>yes</b> - no
Ideas boxes	.....	<b>yes</b> - no
In-place editing	.....	<b>yes</b> - no
Vector-based line links (or)	.....	<b>yes</b> - no
Bit-mapped based line links	.....	yes - <b>no</b>
Maximise work space	.....	<b>yes</b> - no
Note pad	.....	<b>yes</b> - no
Virtual work space	.....	<b>yes</b> - no

Note any points of interest relating to kinds of basic process-based facilities the application should support:

*Work space can be maximised by hiding the menu bar and enabling all menu options to be accessible from a pop-up menu operated by pressing the right-hand mouse button.*

**NB: An application designed to support the mapping process should include as many of the facilities listed above as the implementation language allows.**

**Section 7: Identifying the kinds of advanced process-based facilities which should be provided**

Tick the following advanced *process-based* facilities required in the application:

Bring to front / send to back .....	<u>yes</u> - no
Electronic report .....	yes - <u>no</u>
Ideas pad .....	<u>yes</u> - no
Paragraph text .....	<u>yes</u> - no
Pop-up menus .....	<u>yes</u> - no
Printed report .....	yes - <u>no</u>
Reasoning .....	yes - <u>no</u>
Record/recall .....	<u>yes</u> - no
Style sheets .....	<u>yes</u> - no
Template support .....	<u>yes</u> - <u>no</u>
Text I/O .....	<u>yes</u> - no

Note any points of interest relating to kinds of advanced process-based facilities the application should provide:

*-Some limited template support will be given, in that new files will be based upon a template which the user can access and amend, as they wish.*

*- The user will be able to have the option to have all selected boxes to be automatically 'brought to the front'. This is to side-step the problem of ideas getting obscured by other ideas.*

**NB1: Users not working on 17" monitors will benefit from the provision of pop-up menus, especially if those menus allow other menu bars and tool bars to be dispensed with.**

**NB2: Text I/O is important for those who want to organise ideas prior to exporting those ideas to a WP.**

**NB3: Causal maps require the provision of tools which allow arrowhead lines.**

## Section 8: Describing the process-based facilities in more depth

**NB: The following lists will help to focus on the implementation details relating to some of the more complex facilities outlined previously.**

**Outline the kinds of reasoning systems required (if any):**

*None - BrainBox is not designed to support formal maps, and so it is not possible for the computer to make inferences about the maps drawn.*

**Outline the kinds of report systems required (if any):**

*No automated report facilities are needed. BrainBox will provide many facilities to enable users to manipulate ideas, and so an automated report system would appear superfluous to the utility of the system.*

**List the kinds of autowrite facilities required (if any):**

- |                                  |                 |
|----------------------------------|-----------------|
| Current map to defined pad ..... | <u>yes</u> - no |
| Any pad to current map .....     | <u>yes</u> - no |
| Any map to current map .....     | <u>yes</u> - no |
| Any pad to defined pad .....     | <u>yes</u> - no |
| Other .....                      | yes - <u>no</u> |
- (If yes, then explain...)

**Note any points of interest relating to the kinds of autowrite facilities which the application should support:**

*Rather than integrate the autowrite with the note pad (as on the prototype KwikSort) BrainBox will introduce the concept of an AutoWrite window, which will provide a number of different autowrite facilities. Importantly, from the experience gained during the KwikSort research, the window should not be more than a mouse click away, and must not take more than a fraction of a second to open - or else it will not be used.*

**List the kinds of creative thinking facilities required (if any):**

APC	.....	<u>yes</u> - no
PMI	.....	<u>yes</u> - no
GS	.....	<u>yes</u> - no
OPV	.....	<u>yes</u> - no
ADI	.....	<u>yes</u> - no
EBS	.....	<u>yes</u> - no
VLW	.....	<u>yes</u> - no
C&S	.....	<u>yes</u> - no
FiFo	.....	<u>yes</u> - no
RG	.....	<u>yes</u> - no
PO	.....	<u>yes</u> - no
1+1	.....	<u>yes</u> - no
BS	.....	<u>yes</u> - no
Other		<u>yes</u> - no (if yes, then define...)

**Outline the additional creative thinking options, which are to be implemented (if any):**

- *Implement a 'business workshop', using SSM as a creative thinking option.*
- *Implement a 'writer's workshop' to support the creation of story lines, the creation of characters, outlines for reports, and outlines for theses.*
- *The creative thinking module must not be more than a mouse click away, and must not take more than a fraction of a second to open, or it will not be used.*

**List the kinds of note pads required (if any):**

- Central storage pad(s) ..... **yes** - no
  - Import pad(s) ..... **yes** - no
  - Export pad(s) ..... **yes** - no
  - Other ..... yes - no
- (If yes, then define...)

**Note any ideas relating to the note pad facilities (if any):**

*The note pads should act as separate modules, which enable notes to be saved as text files, or text files to be opened and imported as blocks of notes. Accessing a note pad should take no more than a mouse click from any point in the program, and the pads must open within a fraction of a second - or else the pads are unlikely to be used.*

*Section 9: Identifying the kinds of basic presentational facilities which should be provided*

Tick the basic *presentational* facilities required in the application:

Arrow links	.....	<u>yes</u> - no
Extended text options	.....	<u>yes</u> - no
Print current page	.....	<u>yes</u> - no
Simple zoom	.....	<u>yes</u> - no

*NB: Although many mappers mainly want to use concept maps as a form of mental scaffolding, they may still want a set of basic presentational facilities, to allow them to print out their maps for future reference.*

Note any points of interest relating to the basic presentational facilities the application should provide :

*- Although extended text options will be provided, it is expected that style sheets and the record/recall facilities will be the more common ways in which users make changes to the appearance of boxes and text.*

*- Ideally there would be a simple zoom facility; however, this may not be possible in the initial version of BrainBox because of technical difficulties. This is not seen as a particular problem, since many people in the KwikSort study reported that they preferred to work within the confines of the screen.*

**List the virtual work space facilities required (if any):**

Up to A4	.....	<b>yes</b> - no
Up to A3	.....	yes - <b>no</b>
Larger than A3	.....	yes - <b>no</b>
Other	.....	yes - <b>no</b>

(If yes, then define...)

**If the system is to support extended text options, define those options.**

Cut text	.....	<b>yes</b> - no
Copy text	.....	<b>yes</b> - no
Paste text	.....	<b>yes</b> - no
Change font	.....	<b>yes</b> - no
Change size	.....	<b>yes</b> - no
Change style	.....	<b>yes</b> - no
Change fore colour	.....	<b>yes</b> - no
Change back colour	.....	<b>yes</b> - no
Others	.....	yes - <b>no</b>

(if yes, then define...)

Note any points of interest relating to the extended text facilities or the virtual work space facilities the application should provide :

*Most people print to A4, and so the provision of an A4 work space mirrors the medium on which many mappers may decide to store their work.*

**NB: The extended text table lists a number of the text options normally available in graphics applications and word processors.**



**Section 10: Identifying the kinds of advanced presentational facilities which should be provided**

Tick the advanced *presentational* facilities required in the application:

Annotated links	.....	yes - <b>no</b>
Bit-mapped output	.....	yes - <b>no</b>
Custom zoom	.....	yes - <b>no</b>
Display as hypertext stack	.....	yes - <b>no</b>
Extended graphics options	.....	yes - <b>no</b>
Magnetic links	.....	yes - <b>no</b>
Notes	.....	yes - <b>no</b>
Print all pages	.....	yes - <b>no</b>
Print selected objects	.....	yes - <b>no</b>
Spell checker	.....	yes - <b>no</b>
Vectored output	.....	yes - <b>no</b>
Other	.....	yes - <b>no</b>

(If yes, then define...)

Note any points of interest relating to kinds of advanced presentational facilities the application should support :

*Implementing advanced graphics options would take a long time, and would simply duplicate facilities already available in other programs. It is intended to provide BrainBox with OLE2 compliance, so that it can recreate maps in a presentation-oriented application, should a high level of presentation be required.*

**NB: The presentational facilities which a mapper will find useful will depend upon the kind of presentation the mapper needs.**

## Section 11: Describing the extended graphics facilities in more depth

If the system is to support extended graphics options, define those options.

Bezier curves	.....	yes - <b>no</b>
Blend	.....	yes - <b>no</b>
Combine	.....	yes - <b>no</b>
Copy objects	.....	yes - <b>no</b>
Cut objects	.....	yes - <b>no</b>
Define border width	.....	yes - <b>no</b>
Define fill	.....	yes - <b>no</b>
Duplication	.....	yes - <b>no</b>
Flip horizontal	.....	yes - <b>no</b>
Flip vertical	.....	yes - <b>no</b>
Fragment	.....	yes - <b>no</b>
Glue	.....	yes - <b>no</b>
Gradient fill	.....	yes - <b>no</b>
Group/ungroup	.....	yes - <b>no</b>
Guides	.....	yes - <b>no</b>
Horizontal align objects	.....	yes - <b>no</b>
Paste objects	.....	yes - <b>no</b>
Print preview	.....	yes - <b>no</b>
Resize objects	.....	yes - <b>no</b>
Rotation	.....	yes - <b>no</b>
Rulers	.....	yes - <b>no</b>
Snap to grid	.....	yes - <b>no</b>
Solid fill	.....	yes - <b>no</b>
Union	.....	yes - <b>no</b>
Vertical align objects	.....	yes - <b>no</b>
Others	.....	yes - <b>no</b> (if yes, then define...)

Note any points of interest relating to kinds of extended graphics presentational facilities the application should support :

*These kinds of facilities are already provided in other mapping applications. They are too complex to re-implement in BrainBox at the present time.*

**NB: The table presented above is based on an analysis of the graphics facilities commonly available in many commercial charting and graphics applications.**

*Section 12: Taking into account the context in which mapping occurs*

Identify the contexts in which mapping is expected to take place:

- Solo ..... **yes** - no
- Small group - present ..... **yes** - no
- Small group - distributed ..... yes - **no**
- Large group - present ..... **yes** - no
- Large group - distributed ..... yes - **no**

Tick the *group* facilities which might be useful:

- Grid input ..... **yes** - no
- Notice board access ..... yes - **no**

Note points of interest relating to *group* facilities:

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**NB1:** *Group-based mapping may require additional facilities to be provided. The group may not want to map directly into a computer, because a single mouse input does not allow people to feel the same 'hands on' experience that is found when mapping on a table top.*

**NB2:** *Grid input enables a table top map to be input with a minimum of effort.*

**NB3:** *Notice-board access, on the other hand, allows groups who are distributed in time or geographical space to use maps as a medium of communication.*

## Section 13: The adaptability of the program

### OLE implementation

- Assessed system acts as an OLE2 module extending the functionality of an existing system. ..... yes - **no**
- OLE2 sharing of data from the assessed system to other systems ..... **yes** - no
- OLE2 sharing of facilities in other systems with the assessed system. .... yes - **no**
- Other ..... yes - no  
(If yes, then explain...)

### Note points of interest relating to OLE2 compliance:

*The OLE implementation will be simple, and will seek to prevent data being trapped in BrainBox, when a user wants to convert a rough map into something more presentable.*

**NB: OLE2 enables modules to be added to existing program's, and allows the customisation of an existing program's front end.**

## Section 14: Help facilities

Tick any of the following support facilities which might be required:

An interface which integrates well with other applications, with which the user is familiar. .... yes - no

Context-sensitive help relating to the application. .... yes - no

On-line help relating to application. .... yes - no

On-line tutorial relating to application .... yes - no

On-line information relating to mapping goals. .... yes - no

On-line information relating to map designs. .... yes - no

On-line information relating to mapping media. .... yes - no

Note points of interest relating to help facilities:

*With the resources available, the best way to provide on-line help will be to provide a set of electronic text files, which the user can read or print out. A better option would be to also provide a Windows style help system, but there will not be time to implement this in the first version of BrainBox.*

**NB: Many users may be first-time or infrequent users, and inexperienced in the use of mapping techniques. Consider what support these users might require.**

## Section 15: File facilities

Identify the contexts in which mapping is expected to take place:

Close	.....	<b>yes</b> - no
Exit	.....	<b>yes</b> - no
File info	.....	yes - <b>no</b>
New	.....	<b>yes</b> - no
Open	.....	<b>yes</b> - no
Print preview	.....	yes - <b>no</b>
Print set up	.....	<b>yes</b> - no
Save	.....	<b>yes</b> - no
Save as	.....	<b>yes</b> - no
Other	.....	yes - <b>no</b> (If yes, then explain...)

Note points of interest relating to file facilities:

- Allow files to be saved as templates. This means there will have to be a file extension referring to templates and one referring to maps.

- Print preview will not be implemented in the first version of BrainBox, for the same technical reasons that the simple zoom facility is not to be implemented.

**NB:** The table above is a list of file facilities normally found in word processors and graphics packages, which have not previously been mentioned.

*Section 16: If reviewing an existing system, what facilities does the system provide, and what facilities need to be added*

**NB: If you are reviewing an existing computer-based mapping application, use your previous answers to determine what facilities (if any) need to be added to the existing system...**

*Not applicable...*

Facility	Implemented?	Needed?	Comments...?
Autowrite	yes - no	yes - no	
Easy input	yes - no	yes - no	
Expand facility	yes - no	yes - no	
Ideas boxes	yes - no	yes - no	
In-place editing	yes - no	yes - no	
Vector-based line links (or)	yes - no	yes - no	
Bit-mapped based line links			
Maximise work space	yes - no	yes - no	
Note pad	yes - no	yes - no	
Virtual work space	yes - no	yes - no	
Electronic report	yes - no	yes - no	
Ideas pad	yes - no	yes - no	
Paragraph text	yes - no	yes - no	
Pop-up menus	yes - no	yes - no	
Printed report	yes - no	yes - no	
Reasoning	yes - no	yes - no	
Record/recall	yes - no	yes - no	
Style sheets	yes - no	yes - no	
Template support	yes - no	yes - no	
Text I/O	yes - no	yes - no	
Arrow links	yes - no	yes - no	
Extended text options	yes - no	yes - no	
Print current page	yes - no	yes - no	
Simple zoom	yes - no	yes - no	
Annotated links	yes - no	yes - no	
Bit-mapped output	yes - no	yes - no	
Custom zoom	yes - no	yes - no	
Display as hypertext stack	yes - no	yes - no	
Extended graphics options	yes - no	yes - no	
Magnetic links	yes - no	yes - no	
Notes	yes - no	yes - no	
Print all pages	yes - no	yes - no	
Print selected objects	yes - no	yes - no	
Spell checker	yes - no	yes - no	
Vectored output	yes - no	yes - no	
Grid input	yes - no	yes - no	
Notice board access	yes - no	yes - no	

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Facility	Implemented?	Needed?	Comments...?
OLE2	yes - no	yes - no	
An interface which integrates well with other applications with which the user is familiar	yes - no	yes - no	
Context-sensitive help relating to the application	yes - no	yes - no	
On-line help relating to the application	yes - no	yes - no	
On-line tutorial relating to the application	yes - no	yes - no	
On-line information relating to mapping goals	yes - no	yes - no	
On-line information relating to map designs	yes - no	yes - no	
On-line information relating to mapping media	yes - no	yes - no	
Close	yes - no	yes - no	
Exit	yes - no	yes - no	
File info	yes - no	yes - no	
New	yes - no	yes - no	
Open	yes - no	yes - no	
Print preview	yes - no	yes - no	
Print set-up	yes - no	yes - no	
Save	yes - no	yes - no	
Save as	yes - no	yes - no	
Other	yes - no	yes - no	

*Not applicable...*



## Section 17: Customising an existing system

Note points of interest relating changes which would need to be made to get an assessed application up to an operational level, and how it would be feasible to do this:

*Not applicable...*

**NB: If this checklist has been used to analyse the utility of an existing application, it is worth noting what facilities would be needed to bring the application up to an operational level - and whether it would be feasible for these changes to be made.**

## Section 18: Conclusions

Write any concluding comments below:

BrainBox will need to be implemented in a fast language. The need to access windows quickly, and to be able to manipulate ideas in both text and map formats, suggests the use of a language such as Visual Basic or Visual C++. The need for OLE2 compliance suggests that Visual Basic should be the language of choice.

**NB: This may be a good place in which to write some notes about the programming language in which the new application will be written.**

# **Appendix 5**

## **The final CBMA-Checklist**

**Note: This is the final version of the CBMA-Checklist. The Checklist is available in electronic form to users of BrainBox 3.0 and higher.**

# CBMA-Checklist

**A checklist for use when  
designing or reviewing  
computer-based mapping applications**

**Name of application: .....**

## Section 1: Mapping goals

Identify the mapping goals  
which the application should support:

Warm-up goals	.....	yes - no
Knowledge goals	.....	yes - no
Feedback goals	.....	yes - no
Recall goals	.....	yes - no
Problem goals	.....	yes - no
Solution goals	.....	yes - no
Preparation goals	.....	yes - no
Overview goals	.....	yes - no
Descriptive goals	.....	yes - no

Identify any points of interest relating to mapping goals:

### Notes:

1. *Warm up goals* relate to the need for students to prepare prior to a course of study; *knowledge goals* relate to the need to collate notes and ideas; *feedback goals* relate to the need to assess student attainment; *recall goals* relate to the need to remember information; *problem goals* relate to need to get to the root of a problem; *solution goals* relate to the need to transform creative ideas into a viable course of action; *preparation goals* relate to the need to prepare a presentation; *overview goals* relate to the need for a map-based overview to complement a presentation; *descriptive goals* relate to the need for an exact representation of the domain being mapped.

## Section 2: Kinds of map design

Identify the kinds of map design, which the mapping application should be capable of supporting:

Spatial maps	.....	yes - no
Informal maps	.....	yes - no
Formal maps	.....	yes - no
Simple template maps	.....	yes - no
Complex template maps	.....	yes - no

Identify any points of interest relating to map design:

### Notes:

**1. All mapping goals with the exception of descriptive goals, are most quickly attained through concept sorting (i.e. the development of a spatial map), the results of which are then converted into a concept map or causal map (both of which are informal designs)**

**2. The use of template designs can be helpful:**

- \* when a suitable template exists for a well defined task;
- \* when the mapper is inexperienced; or,
- \* when the subject is complex.

**This is because a template can direct the mapper's attention towards the salient aspects of the subject being mapped.**

### Section 3: Template map designs

***If the application is to provide the user with pre-defined templates, identify templates which are to be supported, from the list below:***

Soft System Methodology	.....	yes - no
Assessment continua	.....	yes - no
Causal chains	.....	yes - no
Crossword	.....	yes - no
Force-field diagrams	.....	yes - no
Story lines	.....	yes - no
Tables	.....	yes - no
Graphs	.....	yes - no
Time lines	.....	yes - no
Vee diagrams	.....	yes - no
Venn diagrams	.....	yes - no
Other	.....	yes - no

*(If yes, then define...)*

***If the application is to enable users to produce their own templates, identify templates which are to be supported, from the list below:***

Soft System Methodology	.....	yes - no
Assessment continua	.....	yes - no
Causal chains	.....	yes - no
Crossword	.....	yes - no
Force-field diagrams	.....	yes - no
Story lines	.....	yes - no
Tables	.....	yes - no
Graphs	.....	yes - no
Time lines	.....	yes - no
Vee diagrams	.....	yes - no
Venn diagrams	.....	yes - no
Other	.....	yes - no

*(If yes, then define...)*

## Section 4: Protocol

Identify the mapping protocol which mappers are expected to use:

Disclosure protocol	.....	yes - no
Organic protocol	.....	yes - no
Step protocol	.....	yes - no

Identify any points of interest relating to mappers:

**Note:**

- 1. Organic protocol involve mappers adding and sorting a few ideas at a time.**
- 2. Step protocol involve mappers generating most of their ideas prior to sorting, for example by importing information from a database.**
- 3. Disclosure protocol involve mappers generating a map in their mind's eye, before externalising that map before it is lost from memory.**



## Section 5: Presentational facilities

Determine whether the following kinds of facilities would make the mapper's work easier :

A basic set of process-based facilities	.....	yes - no
An advanced set of process-based facilities	.....	yes - no
A basic set of presentational facilities	.....	yes - no
An advanced set of presentational facilities	.....	yes - no
Other	.....	yes - no <i>(If yes, then explain...)</i>

Identify any points of interest relating to the kinds of facilities the application should support:

**Note:**

**1. All mapping goals, except for overview mapping and descriptive mapping, are at least, if not more, concerned with process than they are with presentation.**

**2. Presentation (and thus the provision of complex presentational tools) only becomes an issue when using a complex formal map design. Otherwise, the provision of relatively simple presentational tools should enable a level of presentation adequate to keep maps for future reference or to distribute to others.**

## Section 6: Basic process-based facilities

Tick the following basic *process-based* facilities required in the application:

AutoWrite	.....	yes - no
Easy input	.....	yes - no
Expand facility	.....	yes - no
Ideas boxes	.....	yes - no
In-place editing	.....	yes - no
Vector-based line links (or)	.....	yes - no
Bit-mapped based line links	.....	yes - no
Maximise work space	.....	yes - no
Note pad	.....	yes - no
Virtual work space	.....	yes - no

Identify any points of interest relating to basic process-based facilities:

**Note:**

**1. An application designed to support the mapping process should include as many of the facilities listed above as the implementation language allows.**

## Section 7: Advanced process-based facilities

Tick the following advanced *process-based* facilities required in the application:

Bring to front / send to back .....	yes - no
Electronic report .....	yes - no
Ideas pad .....	yes - no
Paragraph text .....	yes - no
Pop-up menus .....	yes - no
Printed report .....	yes - no
Reasoning .....	yes - no
Record/recall .....	yes - no
Style sheets .....	yes - no
Template support .....	yes - no
Text I/O .....	yes - no

Identify any points of interest relating to advanced process-based facilities:

**Note:**

- 1. Users not working on 17" monitors will benefit from the provision of pop-up menus, especially if those menus allow other menu bars and tool bars to be dispensed with.**
- 2. Text I/O is important for those who want to organise ideas prior to exporting those ideas to a WP.**
- 3. Causal maps require the provision of tools which allow arrowhead lines.**

## **Section 8: Describing process-based facilities in more depth**

**Note:**

**1. The following lists will help to focus on the implementation details relating to some of the process-based facilities outlined previously...**

**Outline the kinds of reasoning systems required (if any):**

**Outline the kinds of report systems required (if any):**

**List the kinds of AutoWrite facilities required (if any):**

Current map to defined pad .....	yes - no
Any pad to current map .....	yes - no
Any map to current map .....	yes - no
Any pad to defined pad .....	yes - no
Other .....	yes - no

*(If yes, then explain...)*

**Identify any points of interest relating to AutoWrite facilities:**

**Note:**

**1. AutoWrite facilities enable ideas to be quickly copied between maps and between modules within a mapping application. In addition, they facilitate the copying of ideas from text format to map format, and back again.**

**List the kinds of creative-thinking facilities required (if any):**

APC	.....	yes - no
PMI	.....	yes - no
GS	.....	yes - no
OPV	.....	yes - no
ADI	.....	yes - no
EBS	.....	yes - no
VLW	.....	yes - no
C&S	.....	yes - no
FiFo	.....	yes - no
RG	.....	yes - no
PO	.....	yes - no
1+1	.....	yes - no
BS	.....	yes - no
Other		yes - no

*(If yes, then define...)*

**Outline the additional creative-thinking options, which are to be implemented (if any):**

**Note:**

**1. Adding support for creative thinking is useful if the mapping application is to be used for solution mapping. The facilities listed above are just a few of those available, representing a cross-section of the techniques developed by Edward DeBono.**

**List the kinds of note pads required (if any):**

Central storage pad(s)	.....	yes - no
Import pad(s)	.....	yes - no
Export pad(s)	.....	yes - no
Other	.....	yes - no

*(If yes, then define...)*

**Identify any ideas relating to the note pad facilities:**

**Note:**

- 1. Note pads provide a place to store ideas in a textual format, away from the map surface.**
- 2. A central store is useful when it is combined with some kind of AutoWrite facility, because it gives the user the flexibility to decide on how best to generate and sort their ideas.**
- 3. An import pad makes it easier to import blocks of text from a word processor or data base.**
- 4. An export pad makes it easier to export ideas as a block of text to a word processor or data base.**

## Section 9: Basic presentational facilities

Tick the basic *presentational* facilities required in the application:

Arrow links	.....	yes - no
Extended text options	.....	yes - no
Print current page	.....	yes - no
Simple zoom	.....	yes - no
Virtual work space	.....	yes - no

Identify any points of interest relating to the basic presentational facilities :

**Note:**

**1. Although many mappers mainly want to use maps as a form of mental scaffolding, they may still want a set of basic presentational facilities, to allow them to print out their maps for future reference, or to give to others.**



**List the virtual work space facilities required (if any):**

Up to A4	.....	yes - no
Up to A3	.....	yes - no
Larger than A3	.....	yes - no
Other	.....	yes - no

*(If yes, then define...)*

**If the system is to support extended text options, define those options.**

Cut text	.....	yes - no
Copy text	.....	yes - no
Paste text	.....	yes - no
Change font	.....	yes - no
Change size	.....	yes - no
Change style	.....	yes - no
Change fore colour	.....	yes - no
Change back colour	.....	yes - no
Other	.....	yes - no

*(If yes, then define...)*

**Identify any points of interest relating to the extended text facilities or the virtual work space facilities:**

**Note:**

**1. The extended text table lists a number of the text options normally available in graphics applications and word processors.**

## Section 10: Advanced presentational facilities

Tick the advanced *presentational* facilities required in the application:

Annotated links	.....	yes - no
Bit-mapped output	.....	yes - no
Custom zoom	.....	yes - no
Display as hypertext stack	.....	yes - no
Extended graphics options	.....	yes - no
Magnetic links	.....	yes - no
Notes	.....	yes - no
Print all pages	.....	yes - no
Print selected objects	.....	yes - no
Spell checker	.....	yes - no
Vectored output	.....	yes - no
Other	.....	yes - no

*(If yes, then define...)*

Identify any points of interest relating to kinds of advanced presentational facilities:

**Note:**

**1. The presentational facilities which a mapper will find useful will depend upon the kind of presentation the mapper needs to create. Any, or all, of the presentational facilities currently found in high-end graphics packages may be important.**

## Section 11: Extended graphics facilities

**If the system is to support extended graphics options, define those options:**

Bezier curves	.....	yes - no
Blend	.....	yes - no
Combine	.....	yes - no
Copy objects	.....	yes - no
Cut objects	.....	yes - no
Define border width	.....	yes - no
Define fill	.....	yes - no
Duplication	.....	yes - no
Flip horizontal	.....	yes - no
Flip vertical	.....	yes - no
Fragment	.....	yes - no
Glue	.....	yes - no
Gradient fill	.....	yes - no
Group/ungroup	.....	yes - no
Guides	.....	yes - no
Horizontal align objects	.....	yes - no
Paste objects	.....	yes - no
Print preview	.....	yes - no
Resize objects	.....	yes - no
Rotation	.....	yes - no
Rulers	.....	yes - no
Snap to grid	.....	yes - no
Solid fill	.....	yes - no
Union	.....	yes - no
Vertical align objects	.....	yes - no
Others	.....	yes - no

*(If Yes, then define...)*

**Identify any points of interest relating to the extended graphics facilities:**

*(Please write notes on the reverse of this page...)*

**Note:**

**1. The table presented above is based on an analysis of the graphics facilities commonly available in many commercial charting and graphics applications. (It is not to be taken as definitive!)**

## Section 12: Mapping context

Identify the contexts in which mapping is expected to take place:

Solo	.....	yes - no
Small group - real-time	.....	yes - no
Small group - distributed	.....	yes - no
Large group - real-time	.....	yes - no
Large group - distributed	.....	yes - no

Tick the *group* facilities which might be useful:

Grid input	.....	yes - no
Notice board access	.....	yes - no

Identify points of interest relating to *group* facilities:

**Note:**

**1. Group-based mapping may require additional facilities to be provided. The group may not want to map directly into a computer, because a single mouse input does not allow people to feel the same 'hands on' experience that is found when mapping on a table top.**

**2. Grid input enables a table-top map to be input with a minimum of effort.**

**3. Notice-board access enables groups who are distributed in time or geographical space to use maps as a medium of communication.**

## Section 13: The adaptability of the program

### OLE implementation

Assessed system acts as an OLE2 module extending the functionality of an existing system. .... yes - no

OLE2 sharing of data from the assessed system to other systems ..... yes - no

OLE2 sharing of facilities in other systems with the assessed system. .... yes - no

Other ..... yes - no

*(If yes, then explain...)*

Identify points of interest relating to OLE2 compliance:

**Note:**

**1. OLE2 enables modules to be added to existing programs, and allows the customisation of an existing program's front end.**

## Section 14: Help facilities

**Tick any of the following support facilities which might be required:**

- |   |       |          |
|---|-------|----------|
| An interface which integrates well with other applications with which the user is familiar. | ..... | yes - no |
| Context-sensitive help relating to the application.   | ..... | yes - no |
| On-line help relating to the application.   | ..... | yes - no |
| On-line tutorial relating to the application  | ..... | yes - no |
| On-line information relating to mapping goals.  | ..... | yes - no |
| On-line information relating to map designs.  | ..... | yes - no |
| On-line information relating to mapping media.  | ..... | yes - no |

**Identify points of interest relating to help facilities:**

**Note:**

**1. Many users may be first time or infrequent users, and inexperienced in the use of mapping techniques. Consider what support these users might require.**

## Section 15: File facilities

Identify the file facilities which will be required:

Close	.....	yes - no
Exit	.....	yes - no
File info	.....	yes - no
New	.....	yes - no
Open	.....	yes - no
Print preview	.....	yes - no
Print set up	.....	yes - no
Save	.....	yes - no
Save as	.....	yes - no
Other	.....	yes - no <i>(If yes, then explain...)</i>

Identify points of interest relating to file facilities:

**Note:**

**1. The table above is a list of file facilities normally found in word processors and graphics packages - facilities which have not previously been mentioned.**

## Section 16: Customising an existing system

**NB: If you are reviewing an *existing* computer-based mapping application, use your previous answers to determine what facilities (if any) need to be added to the existing system...**

Facility	Implemented?	Needed?	Comments...?
AutoWrite	yes - no	yes - no	
Easy input	yes - no	yes - no	
Expand facility	yes - no	yes - no	
Ideas boxes	yes - no	yes - no	
In-place editing	yes - no	yes - no	
Vector-based line links (or)	yes - no	yes - no	
Bit-mapped line links			
Maximise work space	yes - no	yes - no	
Note pad	yes - no	yes - no	
Virtual work space	yes - no	yes - no	
Electronic report	yes - no	yes - no	
Ideas pad	yes - no	yes - no	
Paragraph text	yes - no	yes - no	
Pop-up menus	yes - no	yes - no	
Printed report	yes - no	yes - no	
Reasoning	yes - no	yes - no	
Record/recall	yes - no	yes - no	
Style sheets	yes - no	yes - no	
Template support	yes - no	yes - no	
Text I/O	yes - no	yes - no	
Arrow links	yes - no	yes - no	
Extended text options	yes - no	yes - no	
Print current page	yes - no	yes - no	
Simple zoom	yes - no	yes - no	
Annotated links	yes - no	yes - no	
Bit-mapped output	yes - no	yes - no	
Custom zoom	yes - no	yes - no	
Display as hypertext stack	yes - no	yes - no	
Extended graphics options	yes - no	yes - no	
Magnetic links	yes - no	yes - no	
Notes	yes - no	yes - no	
Print all pages	yes - no	yes - no	
Print selected objects	yes - no	yes - no	
Spell checker	yes - no	yes - no	
Vectored output	yes - no	yes - no	
Grid input	yes - no	yes - no	
Notice-board access	yes - no	yes - no	

*Cont'd overleaf...*



...Cont'd from previous page

<b>Facility</b>	<b>Implemented?</b>	<b>Needed?</b>	<b>Comments...?</b>
OLE2	yes - no	yes - no	
An interface which integrates well with other applications with which the user is familiar	yes - no	yes - no	
Context-sensitive help relating to the application	yes - no	yes - no	
On-line help relating to the application	yes - no	yes - no	
On-line tutorial relating to application	yes - no	yes - no	
On-line information relating to the mapping goals	yes - no	yes - no	
On-line information relating to map designs	yes - no	yes - no	
On-line information relating to mapping media	yes - no	yes - no	
Close	yes - no	yes - no	
Exit	yes - no	yes - no	
File info	yes - no	yes - no	
New	yes - no	yes - no	
Open	yes - no	yes - no	
Print preview	yes - no	yes - no	
Print set-up	yes - no	yes - no	
Save	yes - no	yes - no	
Save as	yes - no	yes - no	
Other	yes - no	yes - no	

**Note points of interest relating to changes which would need to be made to get an existing application up to an operational level, and how it would be feasible to do this:**

**Note:**

**1. If this checklist has been used to analyse the utility of an existing application, it is worth noting what facilities would be needed to bring the application up to an operational level - and whether it would be feasible for these changes to be made.**

## Section 17: Conclusions

Write any concluding comments below:

**Note:**

- 1. This may be a good place in which to write some notes about the programming language in which the new application will be written.**

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