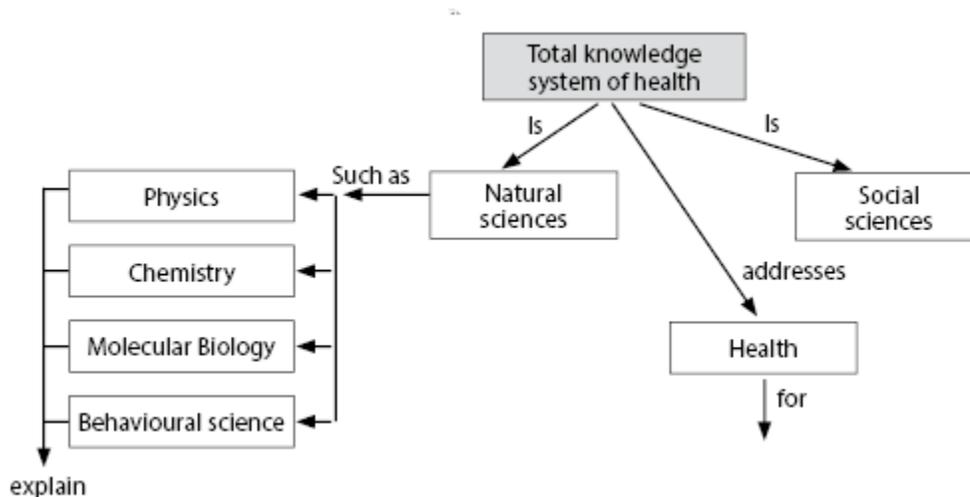# Knowledge Map

Creating and using structural knowledge maps

The idea of a map that shows the structure of knowledge rather than the knowledge itself is something that has been defined here. The main point is to provide a visualization for a knowledge domain. In addition, the visualization will have an independent value because of the method used to create the structure. The knowledge can be managed directly using the map as a focus for discussion and there are fewer implications concerned with definitions.

Concept maps

Concept diagrams / maps are closely related to semantic networks. Concept diagrams are also composed of nodes and arrows that have similar functions. Concept diagrams can be used to describe fairly complex concepts and are suitable for both machine and human interpretation. They are seen as a knowledge representational method that employs graphical structures (Sowa 1984). There is a body of work relating to concept diagrams and their use as a graphical logic (Sowa 1993). This offers interesting opportunities for future work on knowledge mapping by creating the framework that could allow knowledge maps to be transformed into other machine understandable representations such as the Knowledge Interchange Format (KIF) (Genesereth 1992).

Figure 1: Extract of Concept Diagram for knowledge system of health,
         University of Florida – College of Medicine.

Concept diagrams are a powerful way of representing knowledge, of creating a common visualization and also a powerful learning tool. Figure 1 shows a very small portion of a diagram created by the College of Medicine at the University of Florida. The diagram does not require too much explanation because explanatory sentences can easily be created from the diagram itself. The main point to note as far as this reference is concerned is that each arc (or line) has a label that specifies the function of the line. In the work to be described here, arcs have one common function.

Learning dependency

The common function of an arrow for our type of knowledge structure map is "Learning Dependency". Each arc on the knowledge structure map is directional and shows that the target item of knowledge must already be known before it is possible to fully understand (or possibly learn) the source item of knowledge.

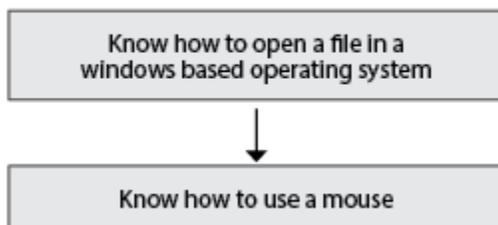Figure 2: Illustration of learning dependency

Figure 2 shows that in order to know how to open a file in a windows-based operating system it is first necessary to know how to use a mouse. It could of course be argued that this is not the case and it is only necessary to know how to use a mouse in order to actually open a file not to know how to do it. However, the concepts of mouse movement and related pointer movement and button clicking would be meaningless without the prior knowledge of how to use a mouse.

Learning dependency is a human centred approach to mapping the structure of knowledge. Learning dependency means that it is necessary to know knowledge "Y" before knowledge "X" can be fully known.

Learning dependency also provides at least some encouragement that it is really knowledge that is being managed. The dependency structure, as used when acquiring expert knowledge, provides some justification as to truth value. One of the reasons I am justified in believing "X" is that I already have knowledge "Y" and "Z" and I know that the knowledge of "X" is dependent on a knowledge of "Y" and "Z".

Attaching parameters to knowledge nodes

Interviews are used as the main vehicle in the construction of structural knowledge maps. During interviews, people are asked to provide information about the structure of knowledge in the domain in question. There are many possibilities as to what this information should be and of course an acknowledgement that interviewees will often need to estimate answers based on their own experience. Several parameters and combinations of parameters have been tested and the following four have been found to be the most useful in all audits.

Importance	How important is the knowledge to the company?
Difficulty	How difficult would it be to replace this knowledge?
Study-Experience	Is the knowledge acquired mainly from study or practice?
Known By	What proportion of the staff in the knowledge area knows this?

Each of these parameters will have a value attached between 0 and 9.
0 –> unimportant, not difficult, none of it, etc.
9 –> core knowledge, very difficult, all of it, etc.

Parameter values are estimates and can be subjective. However some validation does occur during the interview process and it is important to inform managers that the parameters reflect what their staff think and if this is a problem then this may also be something that requires attention.

A map of the structure of knowledge

The interview procedure is fairly rigorous and consists of group and individual interviews. The outcome of the process is a structural knowledge map based on learning dependency with parameter values attached, as identified above. Maps are either viewed with a computer based tool or can be printed out, often on A0 size paper to be hung on a wall.

A typical map will consist of between 60 and 100 knowledge nodes. In order to investigate a knowledge area in more detail than this it would be better to work on separate, linked maps rather than have maps of more than 100 knowledge nodes.

It is difficult to reproduce a full map in a paper like this but the idea can be conveyed through samples. The next two figures are from a self audit of the Applied Knowledge Research Institute (AKRI) which was carried out for demonstration purposes but which actually provided useful information. Figure 3 shows a part of the map without parameter figures. Figure 4 shows the full map without details

Figure 3: Extract from a knowledge structure map
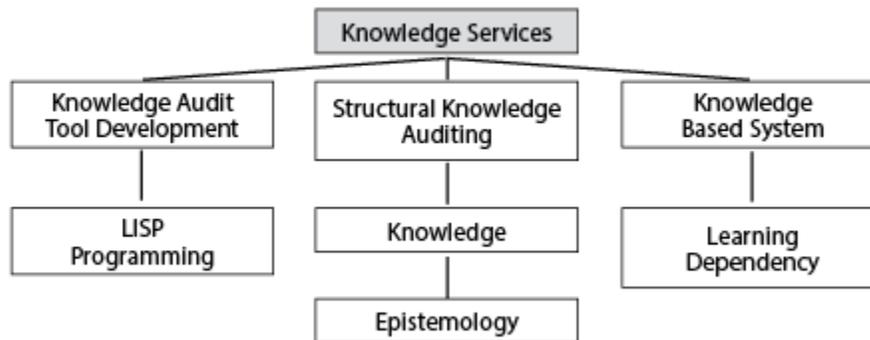
The extract shown in figure 3 is for illustration only and several peripheral arcs and nodes have been removed for clarity and the layout has been changed from that shown in figure 4.

The figure shows that in order to have a full knowledge of the AKRI knowledge services, it is necessary to first have a knowledge of "Knowledge Based Systems", "Structural Knowledge Auditing", etc. In order to know how to do "Structural Knowledge Auditing" it is ecessary to know about "Learning Dependency" (and other things of course). The complete strategic map of the structure of the AKRI knowledge is shown in figure 4.

Figure 4: Strategic level map of the structure of AKRI knowledge
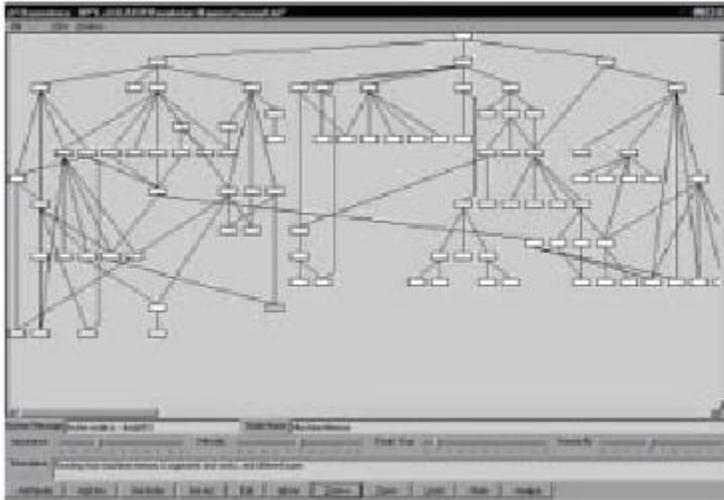
Detail has been omitted from the map but the layout of the support tool has been included to provide an idea of how parameter elicitation is coupled with the elicitation of the structure of knowledge (the software is being written with Harlequin LISP). Managers can manage the knowledge resource by using the structure and leave the truth value to the experts in the knowledge domain.

Analysing the results for management decision making

The software tool that is being developed to support the interview and map creation process, also supports a capability to provide statistical analysis of the map, its structure and the para-meters assigned. The software provides tables of data that are sorted in various ways.

For instance:

- A list of all nodes in alphabetical order along with their parameter values.
- A list of all nodes and parameters in "importance" order.
- A list of all nodes and parameters in "difficulty" order.
- A list of all nodes and parameters in "study-experience" order.
- A list of all nodes and parameters in "knownby" order.
- A list of all nodes and parameters in "risk" order.
- A list of nodes in alphabetical order along with connectivity data.
- A list of nodes with connectivity data in highest prerequisite connectivity.
- A list of nodes with connectivity data in highest postrequisite connectivity.
- A list of all node names, prerequisites and associated notes.

A table showing the most important knowledge or the knowledge known by the least number of staff is useful to support management decision making.

$$Risk = \frac{I + D + S + (10 - K)}{4}$$

Where: I = Importance
D = Difficulty
S = Study / Experience
K = Known By
Values between 0 ... 10

In this case, risk is a derived value and provides additional information for managers to help guide them towards knowledge that may require their urgent attention. In the current system, risk is computed as follows.

Within the context of this work, a risky piece of knowledge is one that is very important to the organization, very difficult to replace, mainly experience based and known by only a few staff.

There is not space here to fully describe all of the information that the process produces.

However, it is important to state that all of the information is intended to inform managers about the state of the knowledge resource and allow them to use their management skills to take decisions and plan action based on the analysis.