

## Article for Asia Pacific Tech Monitor

# Understanding the Human Knowledge Resource using Knowledge Structure Mapping

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### **Abstract:**

An entire discipline called Knowledge Management (KM) has grown over more recent years to account for the high value that organisations now place on knowledge. Unfortunately, the discipline seems to have become very diverse and poorly focused. As a result Knowledge Structure Mapping (KSM) has been developed, following a lengthy collaborative investigation into the knowledge resource. It takes a more focused view of the knowledge resource than the one generally adopted for KM, which means that objective studies of the knowledge resource can be controlled by a well-defined methodology. KSM is part of a Structural Knowledge Auditing (SKA) process that provides a complete knowledge resource tool for organisations.

### **1. Introduction:**

An objective look at what any organisation does, cannot be complete without a careful consideration of what that organisation knows. In particular, what does the organisation need to know in order to enable it to do the things that it does? This is not the same as asking what information does an organisation possess or what information it may need in order to make specific decisions. Rather, it refers to how the decisions are made, how actions are designed and implemented and also knowing what information is needed in order to make decisions etc. This requirement also reaches to parts of an organisation and even job roles. For instance what things does a person need to know in order to carry out the role of Waste management specialist?

#### **1.1 Knowledge Management**

In recent years it has become clearer to many organisations that knowledge is a central issue for the success of that organisation. This was always known implicitly and the reason why so much is spent on recruitment, education and training. However a more explicit view of organisational knowledge is now common and the term 'Knowledge Management' is well used. Unfortunately, the term 'Knowledge Management' (KM) is now also confusing because it has been defined in so many different ways and there have been so many different claims as to how an organisation should implement it. It is not uncommon for an organisation to make a decision that it needs to look at and implement KM but be unable to make any significant progress because it is not clear what should be done.

#### **1.2 Difficulties in Planning Specific Actions**

Several years ago I attended a seminar given by a well-known KM professional to see what others were doing in the area. The main delegates at the seminar were engineering managers from manufacturing companies. The presenter gave a very clear and

professional account of KM. He explained what it was and stated the benefits for any organisation that would invest in KM. The presentation was well received, at least until the question and answer session at the end. Several questions about KM were fielded and answered well by the presenter. That is until one engineering manager stated that his company had already made a decision that it should invest in KM and was ready to do so. The question raised was what exactly should we do first. The questioner wanted a practical straightforward answer to advise on what things the company could actually do to more effectively manage its knowledge. The presenter spent several minutes stating that KM was a diverse field and that there were many things that could be part of a KM initiative. But the engineering manager asked again, yes, but what should we or could we do first, that is now. Again the presenter discussed KM and stated how some organisations had greatly improved by adopting KM. This dialogue continued until the engineering manager gave up with the question.

This little story is based on a real incident and regrettably also highlights a problem felt by many organisations. It is true that there are many things that can be done in the name of KM and that KM is a diverse discipline supporting a wide range of opinion and advice. It is also true that there are many things that are sold under the banner of KM that are really miss-named even though they may be useful things for an organisation to do. The problem with having such a broad ill-defined term such as Knowledge Management is that it becomes very difficult to decide what to actually do about it. The engineering manager from the story above simply wanted to know where to start; he did not want the presenter to solve everything there and then. Unfortunately he left the seminar no wiser than when he entered even though he had listened to a good professional presentation.

### **1.3 Developing a Focused Approach**

The AKRI (formally the NWAIG) has been involved in research, development and implementation in the Knowledge Resource area since 1994. Between 1994 and 1998 the NWAIG carried out a significant collaborative research project that aimed to investigate organisational needs and perceptions concerning knowledge and its use. During this time an experimental software system was developed (known as KM1) that embodied all of the ideas that emerged from the project and formed the foundation and direction of subsequent AKRI activity in this area

Following this early work, the AKRI developed a more focused approach to KM that would have provided the engineering manager from the story above with a definite answer to his question and a complete strategy for a way forward. This article will discuss the organisational knowledge resource and attempt to define what it is. It will then develop an explanation of the approach invented by AKRI and now used internally within Rolls-Royce plc and also employed in specific projects by large and small organisations including BAE Systems. The intention is to show how the most valuable component of an organisational knowledge resource, that knowledge that is in the heads of the expert staff that the organisation employs, can be visualised, evaluated and from there managed. In this way is hoped that readers will be able to see at least one well-defined way forward for developing and protecting the knowledge resource.

## **2. The Human Knowledge Resource:**

A resource is something that is needed in order to achieve some goal. It is the means towards an end. One of the things that an organisation needs in order to function is

knowledge. Often, knowledge is the most important thing that is needed and without it, many of the other resources are ineffective.

## **2.1 Defining Knowledge**

Without delving into a philosophical debate about knowledge, it is nonetheless important to understand what knowledge is in order to understand the knowledge resource. Many will argue that knowledge and particularly a knowledge resource is almost everything that is known by people, written in books, papers, documents, contained on a web site or in a computer database. Aside from being wrong, this would make a knowledge resource very difficult to manage as one thing. Taking a simplified view of knowledge, knowledge is something that someone knows. When someone knows something this is different from simply believing that same thing. Risks taken based on sound knowledge are more justifiable than risks taken that are based on beliefs. This is not the place to discuss knowledge at depth since it is not necessary to have a full understanding in order to appreciate a more general debate about a knowledge resource

## **2.2 A Staff Based Resource**

Taking a more focused view of knowledge means that defining a knowledge resource is much easier. For the sake of this article, I will consider knowledge to be only the things that people know since it has not been established that books, documents or even computers can know things. The knowledge resource for an organisation then is the knowledge that is contained in the heads of the staff that it employs. Apart from being simple, this view has other advantages. For most organisations, whether it is argued that knowledge is kept or stored, the place that it is applied is where the human is. People apply knowledge and are very good at doing this. Even if we argued that knowledge was contained in a vast database of organisational documents, this would still require searching, finding, moving to the place that it was needed and then interpreting and applying by a human. That is not to say that there are not some instances of knowledge based machines and knowledge based software but these are usually far less flexible than a human and very rarely do they update their knowledge or learn from mistakes without human intervention.

The problem with taking this view of the knowledge resource is that it now becomes more difficult to understand how knowledge in the heads of staff can be managed by managers. Some implicit attention to this is done through human resource and educational programmes but operational managers will still have difficulty doing anything explicit about the human knowledge resource.

## **2.3 The Need for Visualisation and Analysis**

In order to manage anything, a manager must have information about it. In most cases it is also necessary to share a common understanding of the thing that is being managed with others who together make operational decisions. If the human knowledge resource as it has been defined here, is to be managed effectively then several things must be done.

1. A common visualisation of the knowledge resource must be created that can be shared and understood by all those that are to use or control it.
2. The visualisation must have a logical construction or easily understandable framework if it is not simply to add confusion to the activity.
3. Information about the knowledge resource must be made available to help managers to make decisions about it and draw conclusions.

This is what we hope that a Knowledge Structure Map (KSM) and its associated data provide. Using a KSM approach, a management group can stand in front of a map and see a knowledge resource. They can point to things that need attention and others can see immediately what is being referred to without confusion. Data provided with the KSM can help the managers to see issues, identify risks and discuss actions. The layout or structure of the KSM can help managers to develop better educational support, to organise team working and to identify knowledge links and overlaps within and across knowledge areas and potentially utilise staff more effectively. It is suggested that the use of the KSM and associated methodology can help an organisation to develop, protect and make better use of its human knowledge resource.

### 3. Knowledge Structure Mapping (KSM):

Within the context of this paper a Knowledge Structure Map (KSM) is something that is created during the application of a well-defined methodology. The KSM can become part of a project known as a Structural Knowledge Audit (SKA) that has been carried out many times in business (see table 2). In this section I will attempt to show what is meant by a KSM and also show some of the additional information that is elicited and analysed as part of an SKA.

In this work, the term 'knowledge structure' is used to refer to knowledge items or labels that are linked together based on their learning dependency. The example in figure 1 illustrates this point.

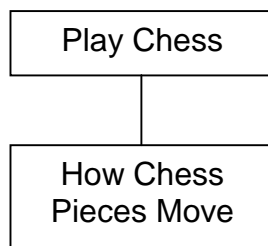
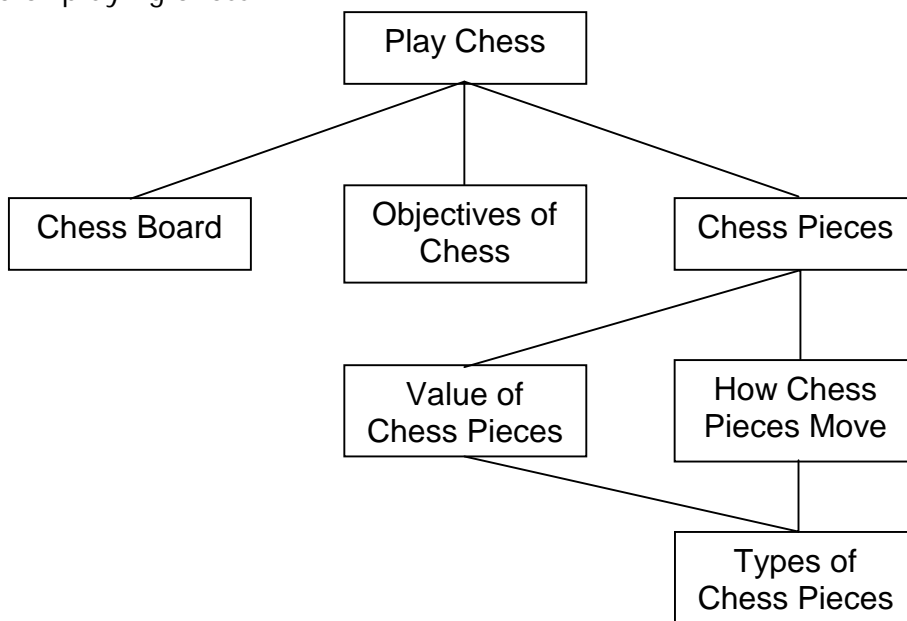


Figure 1: Learning Dependency

Figure 1 illustrates that if someone knows how to play chess then it is assumed that they must already know how chess pieces move on the chessboard.

#### 3.1 Learning Dependency

The example shown in figure 1 takes a simple look at learning dependency by showing that in order to know one thing assumptions about prior knowledge exist. This particular example can be expanded to show more of the knowledge that is prerequisite to the knowledge of playing chess.



### Figure 2: Chess in more detail

Figure 2 considers more of the learning dependency that exists within the knowledge of playing chess. It is still not complete because it misses important areas such as strategy. The interested reader may like to produce a more complete version of the knowledge structure map of chess organised by learning dependency that includes knowledge about strategy etc and expands the areas shown.

In figure 2, there are three knowledge items that are shown as necessary prerequisite knowledge of chess playing and the original prerequisite from figure 1 is not one of these. The knowledge of how chess pieces move is now seen as a necessary prerequisite of the knowledge of chess pieces. This knowledge is seen to rely on a prior knowledge of the value of chess pieces as well. The map shows that both 'value of chess pieces' and 'how chess pieces move' relies on a prior knowledge of the types of chess pieces.

### 3.2 Developing the Knowledge Structure Map

The Knowledge Structure map is the focal point of the entire methodology and must be created with care by people that have some practice and appropriate background knowledge.

### 3.3 Implications of a Learning Dependency Structure

Mapping the structure of knowledge in this way links the map directly with the human knowledge resource because it mirrors the way that expert knowledge is acquired. One of the implications of this is that the map can be used directly to assist in the management of training and education as a knowledge resource development option.

Many organisations waste money by sending the wrong people on training and learning programmes. The organisation is often focused on the outputs of the programme and often ignores the required prerequisite knowledge assumed by it.

Organisations can get more value from testing people before they are sent on a course than after they have finished it (when it is too late).

A learning dependency (knowledge structure) map can show in some detail, what the assumed learning standard of a particular piece of knowledge is. A learning dependency map represents full and complete knowledge for each knowledge node present. That is an expert level knowledge; the level that the organisation would aspire to. It is not desirable or practical that the map should show a proportion of knowledge (say 45%) that it is OK to achieve before moving on to the next level.

### 3.4 Additional Information About the Knowledge Resource

When a knowledge structure map has been created, it contains information that can be of use to the organisation by virtue of its method of construction. The structure of a larger map of about 120 nodes can show knowledge overlap between areas, knowledge subsumed by major work areas, knowledge that is supportive of many other areas etc. An illustration of the sort of analysis available directly from map structure is shown in figure 3. This is a typical map of a business knowledge area where shaded nodes show the knowledge that is common to two major knowledge areas.

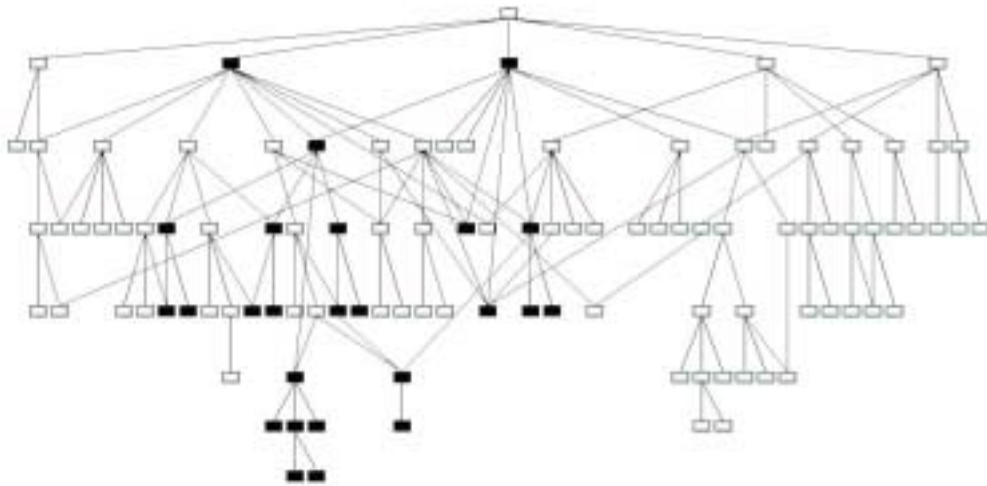


Figure 3: Typical map showing knowledge overlap between two main areas.

The Structural Knowledge Auditing (SKA) methodology includes the elicitation of several parameters concerning each of the knowledge nodes on the map. Parameters are assigned values during interviews. The value of these parameters reflects the views of the experts in the area about each particular item of knowledge. The subjective source of this information is controlled by validation and the methodology includes structures to support validation and conflict resolution. The parameters are listed in table 1.

<i>Parameter</i>	<i>Description</i>
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 know this?

Each of these parameters will have a value attached between 0 and 9.

0 -> unimportant, not difficult, non of it etc.

9 -> core knowledge, very difficult, all of it etc.

Table 1: Knowledge Analysis Parameters

Parameter values can be used in various ways to interrogate the map and provide information to assist managers in the development and protection of the knowledge resource. Knowledge can easily be ordered by parameter value with for instance, the knowledge known by least people appearing at the top of the table. These values can also be reflected as a colour coded map (e.g. a colour coded version of figure 3) where red represents areas requiring most attention. Parameters can also be combined in tables and in colour coding to allow more complex interrogation.

#### **4. Applications of KSM:**

Mapping the structure of knowledge in the manner described earlier has proven to be a powerful organising and representational strategy for a knowledge resource. It focuses on the knowledge that is needed to do the things that an organisation does. One of the main strengths of this method is its focus.

#### 4.1 Expectations and Possibilities

In the second half of 2001, a meeting was held with all of the organisations that had commissioned SKA projects. An improved methodology for SKA resulted from this and several subsequent meetings. The main improvement was in the support offered to organisations concerning the implementation of SKA outputs. Information about what sort of things can be expected from a SKA was made clearer. Typical additional information given includes:

- 1) Typical areas of general concern to organisations include:
  - a. Staff turnover
  - b. Recruitment
  - c. Major Business decisions such as acquisition, outsourcing etc.
  - d. ....
- 2) Typical specific business issues that SKA can address include:
  - a. Identifying knowledge needed in a particular business area
  - b. Uncovering high risk knowledge areas and targeting management action
  - c. Investigating knowledge used in existing processes in order to improve efficiency, delivery, service etc.
  - d. Map a business knowledge area so that it can be relocated or duplicated in other locations
  - e. ....

This list is not exhaustive but reflects the issues brought to the table by the organisations that had actually benefited from these sorts of findings.

#### 4.2 Target Areas for SKA

Table 2 provides some information concerning many of the actual SKA projects that have been carried out. The table shows the topic areas that have been studied for each organisation. It can be noted that the topics studied with SKA have been very diverse. This supports the view that a knowledge resource is part of probably any activity that involves human practitioners.

	<i>AUDIT</i>	<i>SIZE</i>	<i>START</i>	<i>END</i>	<i>TOPIC</i>
1	Aerospace	Large	05:11:98	25:11:98	High Tech Fabrication
2	Prototyping Business	Small			Engineering Prototyping
3	Utility company	Large	12:03:99	26:03:99	Safety
4	Engine Manufacturer	Large	24:01:00	17:02:00	Business Winning
5	Business Consultant	Small	10:04:00	14:04:00	Consultancy Activities
6	Off-licence Retail Group	Small	09:05:00	06:06:00	Off-licence Retail
7	Industrial Doors	Medium	07:06:00	05:07:00	Industrial Door Repair & Service
8	Computer Peripheral	Medium	20:10:00	14:11:00	Engineering Services
9	Computer Peripheral	Medium	18:12:00	06:02:01	Sales & Marketing
10	Computer Peripheral	Medium	16:02:01	27:03:01	After Sales (installation, maintenance)
	Computer Interface	Medium	02:04:01	04:05:01	Cross Audit Analysis
11	Hotel	Medium	25:06:01	13:07:01	Hotel Operations
12	Learning Council	Large	01:02:02	22:02:92	Skill Needs Analysis
13	Learning Centre	Medium	11:11:02	06:12:02	Senior job role study
14	Aerospace	Large	28:04:03	20:06:03	Continuous Improvement

Table 2: SKA projects carried out

Table 2 shows that each project has lasted between 3 and 4 weeks. Project 14 was delayed because of fixing dates for the final presentation and the availability of senior staff but the actual work took about 3 to 4 weeks.

### 4.3 General Findings from the projects

There is only space here to discuss general findings from the projects. These can be considered in several categories.

#### 4.3.1 Parameter Value Results

Each project reveals particular and specific results that can be used to derive recommendations and can in turn be used to inform the decision making process within the business. When results are considered together, some trends do emerge.

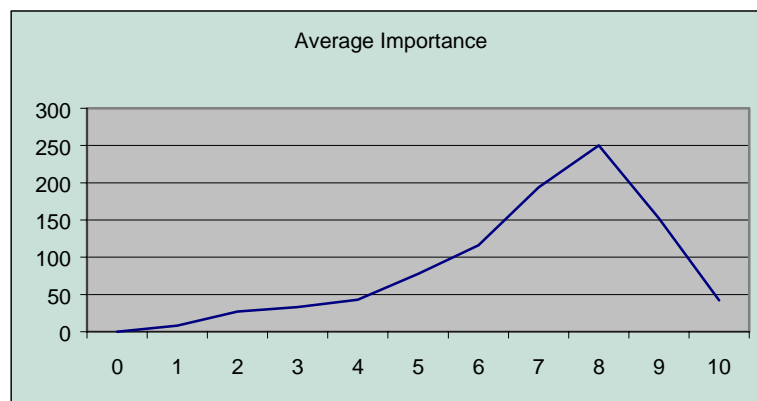


Figure 4: Average project results for importance

Figure 4 shows that staff generally view knowledge as an important resource. This may not be a surprising result but a project result that differs from this trend would be interesting. The graph also shows that there is at least a little knowledge that is considered to be unimportant; why should this be so?

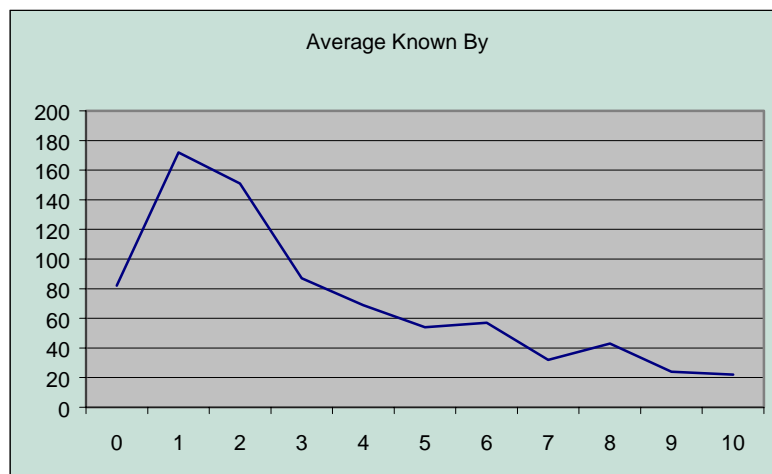


Figure 5: Average project results for Known-By

The graph for numbers of people in a knowledge area that possess individual pieces of knowledge shows that the trend is that the knowledge resource in most organisations is quite specialised. It could be argued that an attempt by management to introduce

effective multi skilling measures should result in moving the peak of figure 5 to the right.

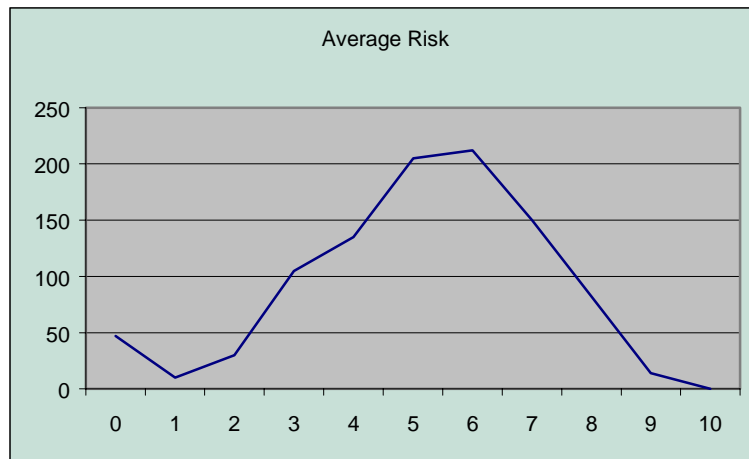


Figure 6: Average project results for knowledge Risk

RISK is defined as knowledge that is most important *and* most difficult to replace *and* gained through experience *and* known by only a few staff. Figure 6 shows that many organisations have some knowledge that can be considered as high risk. Much more of the knowledge resource is medium risk and therefore probably requires sustained if not urgent attention.

#### 4.3.2 Map Connectivity Results

SKA can provide tables of knowledge nodes ordered by the most highly connected. That is, knowledge with the largest prerequisite structures. Tables can also be provided that show which knowledge items are supportive of most other knowledge areas and are therefore key business knowledge components.

Typical results have shown overlap between knowledge areas. Figure 3 was taken from an actual project and the two knowledge areas being tested were 'Installation' and 'Customer Service'. It would be reasonable for a business to for instance, consider outsourcing its installation work so that it could concentrate on what it may see as core business. In this case, the map shows a 31% overlap of knowledge in these two areas. This does not mean that the organisation should not go ahead with outsourcing, only that it should seriously consider the implications and the potential effect on 'customer services' of doing so.

Another study revealed that the knowledge area of 'product storage' underpinned almost 20% of the entire knowledge map for the business. It was also revealed in parallel that this knowledge area was known by very few people in the business and that it would probably be quite difficult to replace it.

#### 4.3.3 Recommendations

Typically recommendations have lead to:

- I. Changes in information disclosure to competitive organisations
- II. Creating knowledge links from Engineering to Marketing to improve performance
- III. Creating an in house training scheme to share key knowledge
- IV. Re-evaluation of knowledge requirement (and function) in a business area
- V. The creation of a comprehensive sector training scheme
- VI. Clarifying and duplicating the knowledge area of Continuous Improvement

## 5. Uses of KSM:

The methodology associated with SKA calls for projects to be completed within 3 to 4 weeks. This means that maps will always be about the same size and similar complexity. It is possible to study quite small well focused knowledge areas such as:

- What do you need to know in order to know how to conduct tests for BT toxin?  
or very much larger knowledge areas such as
- What do you need to know in order to know how to plan and implement Research and Development strategy for Biotechnology in Japan?

The claim that either of these could be done in the same amount of time may seem unrealistic. However, the difference between the two examples would be that the first study would identify considerable detailed knowledge whilst the second study would uncover more strategic and less detailed knowledge. Both KSMs would still be correct and they would both satisfy the claim that they represented their designated knowledge area. Clearly one difficulty with the second study would be to get several experts together to interview. However, if the logistics of the study could be solved the actual project would deliver what it set out to deliver.

### 5.1 Projects in Incremental Stages

If a project is to investigate a large knowledge area and the detail required is significant then the approach would be to carry out several linked sub projects that each took between 3 and 4 weeks. This has several advantages:

- Interim results are delivered early in the full project
- Managers can review interim results and control the subsequent direction of the project
- Managers can review, extend or curtail a project at any of the sub project mileposts

If a single KSM project uncovers a smaller knowledge area that is interesting to the management group but requires further study, a smaller focused study could be carried out on this particular knowledge area. The results of the smaller study could either be integrated with the original map or presented separately. In a study of 'sales and marketing' in an engineering company, the knowledge area of 'negotiation' was identified. In order to clarify this after the initial work was complete, a smaller study of 'negotiation' was undertaken. This led to the creation of a smaller map (about 35 nodes) that had a separate value to the organisation.

### 5.2 Flexible Application

Figure 7 provides a view of three typical KSM study options. An organisation may choose to study one particular knowledge area, creating a stand alone map with associated data and knowledge recommendations based on the study analysis. The organisation may elect to study more knowledge by carrying out several separate studies in the areas identified. Each of these would deliver separate maps, data, analysis and recommendations. However, since the work would be carried out sequentially, the managers of the project would have options at several interim stages to change the study emphasis or direction, to extend the study or to cut it short. The final option depicted in figure 7 is that of a multiple integrated study. Initially one general global map of a large knowledge area would be created. From this, critical knowledge areas would become the target for separate full studies and in this way extend the depth and detail of the original study. Each of these studies would provide their own map, data,

analysis and recommendations but would be integrated because they would all be extensions of the same initial work. This option also shows that smaller focused studies can be made to clarify particular elements of organisational knowledge that has not been fully investigated during the previous studies. A smaller study like this would lead to a small KSM and data, analysis and recommendations would be integrated with the initial study report.

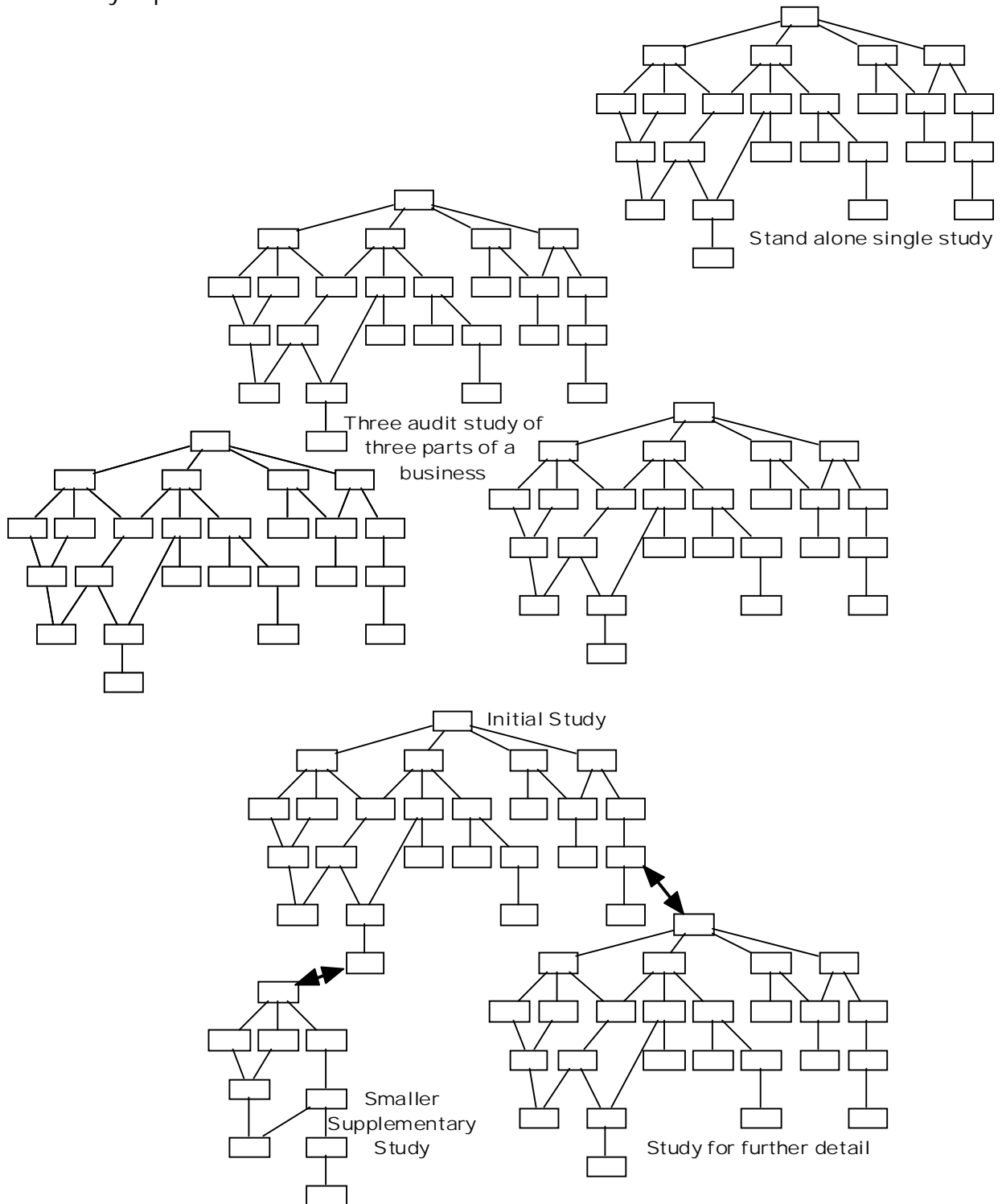


Figure 7: Typical knowledge Study Options

The options presented in figure 7 are only suggestions for how the KSM methodology could be used to explore more or less of an organisational knowledge resource. In practice it would be advisable to take advantage of the flexibility of the methodology

and allow the results of interim work to guide the disclosure of more of the knowledge resource.

### 5.3 Diverse Knowledge Domains

Table 2 shows that studies have been carried out in a very diverse range of knowledge areas covering technical, entirely non-technical and conceptual areas. The claim is that if people need to know something in order to carry out a job role or function then it is possible to analyse that knowledge resource objectively using the KSM approach. Within a small business environment this may include analysis of the knowledge of certain job roles, analysis of planning and logistics and analysis of the knowledge needed for the operation of the business. It would even be possible to study a knowledge related question like:

- What knowledge is needed in order to know how to create and implement a policy to increase the competitiveness of my company in the marketplace?

## 6. Summary:

This article shows that the term Knowledge Management, as it is generally used, is very broad and far-reaching. It is not argued that such views are incorrect, but they are sometimes unhelpful. A story of an engineering manager that wanted to know where his company was to begin with a KM approach highlighted the problems that can arise. A more focused view of knowledge is adopted here and the KSM methodology should be associated with this more focused view and not all of KM. It was also shown that if the knowledge that is in the heads of organisation experts is to be managed at all, then several things must be made available to managers.

The KSM methodology is focused on the creation of a Knowledge Structure Map. This map shows elements of knowledge that are organised in the way that a human expert would be expected to acquire the knowledge. This organisation has been called learning dependency. A KSM is a visualisation of a knowledge resource that can be shared by people that wish to discuss it and make decisions that may affect it. A KSM can provide information directly because of the way that it is constructed. A more complete SKA methodology also identifies some data that relates to the knowledge elements on the map and this data can also reveal issues about the knowledge resource that would be interesting to those that aim to manage it.

The methodology can be applied in several ways and its flexibility is enhanced by the fact that any size of project will have 3 to 4 week delivery points where progress can be discussed, directions can be altered and interim results can be utilised. The methodology can also be used to justify the application of other elements of a broader approach to KM that may consume greater organisational resources. The results and observations delivered from a complete SKA project provide information and decision support to issues relating to a knowledge resource.

### Further Reading:

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