THE DEVELOPMENT OF A KNOWLEDGE MANAGEMENT MODEL TO IMPROVE THE EFFECTIVENESS OF PROJECT MANAGEMENT ORGANISATIONS

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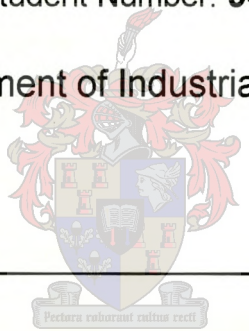

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Study leader: K von Leipzig

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I. DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has never been submitted, in part or in its entirety, at any university, for any requirements towards the achievement of a degree.

Ek, die ondergetekende, verklaar hiermee dat die werk gedoen in hierdie tesis my eie oorspronklike werk is wat nog nie voorheen gedeeltelik of volledig by enige universiteit vir 'n graad aangebied is nie.

II. SUMMARY

The new economy of the world has shifted the emphasis of organisations away from the traditional view that land, labour and capital is needed for competitive advantage, to a view that the knowledge inherent in people is the greatest driver for economic success. This shift from the industrial economy to the information or knowledge economy has prompted an increase in the study of the role knowledge plays in determining organisational success.

The management of this knowledge is of great importance to all organisations competing in the knowledge economy. An organisation that uses the management-by-projects approach is presented with additional challenges. The people who create and use knowledge in project management organisations move from project to project, and project teams are formed temporarily for the duration of the project. In global project management organisations, the impact of the diverse cultures, values and ideals of people is an even greater challenge than in non-project management organisations. People need to co-operate on projects without much time to adjust to these differences.

This has lead to this research study on the management of knowledge in organisations that use the management-by-projects approach. The first aim of the study was to review the relevant literature on knowledge management and project management. A model was developed from the literature that comprises the most important components needed to ensure that all organisational knowledge is used to establish a competitive advantage. This general model was refined to satisfy the needs of a project management organisation.

As mentioned in a previous paragraph the greatest challenge for a project management organisation is harnessing the diversity in project teams and using it to the advantage of the organisation. The diversity in project teams stems from the diversity in value systems of team members and groups within project teams. This also leads to diversity in the cultures within the organisation. These cultures can be racial or national cultures, professional cultures, or functional cultures that are developed when individuals interact within groups.

This thesis aims to emphasise the importance of people, as individuals and groups, and the organisational culture that is formed through the shared values and ideals of such groups. People will be motivated to change their way of work by focussing the implementation of an initiative such as knowledge management on the culture of the organisation. This is because the change is then rooted in their shared values.

The purpose of this study is therefore not only to develop a model, but also to stress the relative importance of the components of the model. The model consists of three enablers: culture, people and technology. These enablers will prepare the organisation to adopt and use the process of knowledge management effectively. The knowledge management process will not be very effective, if the enablers are not implemented successfully.

Implementers of a knowledge management initiative must understand that the organisational culture is of primary importance. The other enablers and the knowledge management process should be supported by the organisational culture.

The model for knowledge management that is developed in this thesis is compared to the implementation plan of a South African technology company that uses the management-by-projects approach. The model that is being implemented at Sasol Technology is critically compared to the model proposed in this thesis.

Conclusions are reached on the gap between the model that is being implemented at Sasol Technology and the model that is developed in this thesis. From this it will be evident that the proposed model could be used as a frame of reference for the implementation of knowledge management in project management organisations.

III. OPSOMMING

Daar is tans 'n klemverskuiwing in die wêreldekonomie, weg van die tradisionele idee dat grond, arbeid en kapitaal benodig word vir kompeterende voordeel. Die nuwe fokus is op mense se kennis as drywer vir ekonomiese sukses. Hierdie verskuiwing vanaf die industriële ekonomie na die inligting- of kennisekonomie het tot gevolg dat die rol van kennis in die sukses van maatskappye ondersoek word.

Die bestuur van kennis is baie belangrik vir alle organisasies wat kompeteer in die kennisekonomie. Vir 'n organisasie wat die bestuur-deur-projekte bestuursbenadering volg, is daar egter nog meer uitdagings. Mense wat binne hierdie omgewing werk word gereeld tussen projekspanne rondgeskuif, dié spanne word ook net gevorm vir die leeftyd van die projek. In internasionale organisasies moet mense van verskillende kulture, met verskillende waardes en ideale, saamwerk op projekte, sonder dat hulle baie tyd het om gewoond te raak aan hierdie verskille.

Dit het gelei tot hierdie navorsingstudie van die bestuur van kennis binne organisasies wat die bestuur-deur-projekte bestuursbenadering gebruik. Hierdie navorsing is begin deur 'n oorsig te neem van die relevante literatuur oor kennisbestuur en projekbestuur. Uit die literatuur is 'n model ontwikkel wat bestaan uit al die belangrikste komponente wat bestuur moet word om te verseker dat al die kennis in ‘n organisasie gebruik word. Die kennis binne die organisasie moet gebruik word om nuwe waarde te skep wat ‘n kompeterende voordeel kan bewerkstellig. Hierdie algemene model is verfyn om die behoeftes van ‘n projekbestuursorganisasie te bevredig.

Soos reeds genoem is die grootste uitdaging vir projekbestuursorganisasies om die diversiteit in projekspanne in te span tot die voordeel van die organisasie. Hierdie diversiteit is afkomstig van die diverse waardestelsels van spanlede en groeperings binne projekspanne, en daarom ook die diverse kulture in organisasies. Dit kan etniese of nasionale kulture, professionele kulture of funksionele kulture wees, wat ontstaan uit die interaksie van individue wat in groepe werk.

Hierdie tesis beklemtoon die belangrikheid van mense, beide as individue en groepe, en ook die organisasiekultuur wat ontstaan as gevolg van die gemeenskaplike waardes en ideale van sulke groepe. Mense kan gemotiveer word om hul manier

van werk te verander deur tydens die implementering van 'n inisiatief soos kennisbestuur te fokus op die kultuur van die organisasie. Dit is moontlik omdat die verandering geanker is in die waardes van die mense.

Die doel van hierdie studie is daarom nie net die ontwikkeling van 'n model vir kennisbestuur nie, maar ook om die relatiewe belangrikheid van die komponente van die model uit te lig. Die model bestaan uit drie bemagtigers (engels: "enablers"): organisasiekultuur, mense en tegnologie. Hierdie bemagtigers berei die organisasie voor sodat die kennisbestuur proses aanvaar en effektief gebruik kan word. Die kennisbestuur proses sal egter nie baie effektief wees as die bemagtigers nie suksesvol geimplementeer is nie.

Die persone wat gemoeid is met die implementering van kennisbestuur moet verstaan dat die organisasiekultuur van primere belang is. Die organisasiekultuur moet ook ondersteun word deur die ander bemagtigers en die kennisbestuur proses.

Die model vir kennisbestuur wat in die tesis ontwikkel is word vergelyk met die implementeringsplan van 'n Suid-Afrikaanse tegnologie maatskappy. Sasol Tegnologie gebruik die bestuur-deur-projekte benadering en daarom kan die model wat in hierdie tesis voorgestel word krities met die maatskappy se model vergelyk word.

Gevolgtrekkings word gemaak oor die gapings tussen die model wat by Sasol Tegnologie gebruik word en die model wat in hierdie tesis ontwikkel is. Hieruit is dit duidelik dat die voorgestelde model gebruik kan word as 'n verwysingsraamwerk vir die implementering van kennisbestuur in projekbestuursorganisasies.

IV. ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their contributions and support. Without their assistance, this project would not have been possible.

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My family and friends, for encouraging and supporting me in all the time it took to complete this work.

V. TERMS OF REFERENCE

This thesis is the result of a research topic, proposed by Sasol, on knowledge management. In 1998, the author was awarded a bursary by Sasol to research the topic as partial fulfilment of the requirements for the degree, Masters of Science in Industrial Engineering.

The scope of the research included a literature study of the general field of knowledge management and the development of a knowledge management model for project management organisations. This was to be a theoretical study with a comparison of the proposed model to the model developed and implemented at Sasol.

The thesis was presented to the Department of Industrial Engineering during December 2002.

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1. INTRODUCTION

In the first part of the previous century the world economy has moved from an agricultural economy to an industrial economy. In the last two decades the shift away from an industrial economy into the information economy has started (Drucker, 2001). Currently the world is starting to move away from the information economy towards an integrated approach to knowledge and information management. This move has resulted in the search for ways to manage the knowledge in organisations.

1.1 BACKGROUND

Knowledge management has become a key strategy for many organisations in the quest to maintain, and even gain a competitive advantage. The leaders of organisations have realised that knowledge is a renewable source of advantage that cannot easily be copied by competitors. With this realisation has come a need to understand the contribution of knowledge to the success of organisations, as well as a method to extract more value out of all sources of organisational knowledge. This method of realising the potential of organisational knowledge and applying knowledge to gain competitive advantage is called knowledge management.

Project management organisations can benefit even more from knowledge management than other organisation forms – owing to the very nature of projects. The definition of a project "*... temporary endeavour undertaken to create a unique product or service.*" (PMI 1996, p. 4) provides two strong arguments to motivate the use of knowledge management in project management organisations. These two arguments are described below.

The uniqueness of projects is the first attribute of importance. Team members cannot learn from repeating tasks under the same circumstances. Although there are similarities between different projects, all circumstances will not be the same. To ensure a high probability of project success, all available knowledge should be used. This includes knowledge gained in similar projects.

The second important attribute of projects is the temporary nature of these endeavours. Project teams work together for a limited time and the temporary project team is disbanded at completion of the project. The tacit knowledge in the minds of people is the most difficult to transfer. In most cases it can only be transferred if the

team member is transferred to a new team. In project management organisations it is important to manage the transfer of these people as well as the tacit knowledge they possess. The explicit or codified knowledge is another aspect of knowledge management that is important in a project management environment.

These arguments demonstrate the need for formal management of knowledge in project organisations moreover; at the time of this writing very little research has been done on the need for and potential advantages of knowledge management in project management organisations.

This study was initiated to satisfy this need for a formal model for knowledge management in project management organisations. Although the field of knowledge management is not mature yet, a great amount of literature on the subject does exist. The aim of this study was to find concepts in the literature that are most relevant to the management of knowledge in project management organisations and to combine these into a model.

This model should be useful to project management organisations in increasing the probability of project success by negating typical causes for poor project performance. This study is therefore a combination of the current bodies of knowledge on project management and knowledge management in order to improve project management.

1.2 STATEMENT OF THE PROBLEM

The organisational knowledge in project management organisations is currently not managed well enough to improve the effectiveness of project management organisations. A knowledge management model specifically designed for project management organisations should therefore be developed to remove the current constraints that lead to poor performance in projects.

1.3 OBJECTIVES AND AIMS

In view of the background discussion leading to the problem statement above, the objective of this work was defined as follows.

1.3.1 OBJECTIVE

To develop a theoretical knowledge management based model that could be used to enhance the performance of project management organisations.

1.3.2 AIMS

To pursue this objective the following aims were designed.

a) Aim 1

To conduct a comprehensive literature review to determine the *status quo* of the knowledge management field, with specific emphasis on the reasons why knowledge management is needed in project management organisations.

b) Aim 2

To compile a comprehensive overview of the literature in the field of project management. The definition of a project management organisation as well as the processes and structures used in project management will be the focus here. The literature study will reveal the typical reasons for poor performance in projects.

c) Aim 3

Having obtained an understanding of the fields of knowledge management and project management from the aims above, the third aim was to develop a knowledge management model to improve the effectiveness of project management organisations. This model will be developed by taking cognisance of the current state of knowledge management and project management and combining existing concepts to fit the specific needs of project management organisations.

d) Aim 4

The final aim of this study is to compare the theoretical knowledge management model that was developed here with the existing model that is being implemented at a South African company that utilises the management-by-projects approach. The comparison of these models will lead to conclusions and recommendations regarding the usefulness of the knowledge management model for project organisations.

1.4 STRUCTURE OF THIS THESIS

The remainder of this thesis document was structured in the following manner. In section 2 the literature survey on knowledge management is discussed. This includes a discussion on the emergence of the knowledge economy and the reasons why knowledge management is needed in organisations.

Section 3 is a discussion of the current state of the field of project management. In this section the factors that lead to poor performance in projects is discussed. The knowledge management model that is developed in this study could be used to address these factors.

The literature study of knowledge management and project management was used as input to develop the knowledge management model for project management organisations that is discussed in section 4. The first chapter in section 4 describes the flow of knowledge and information in project management organisations. The structure of the proposed model is then discussed.

Section 5 and section 6 describe the knowledge management enablers and the knowledge management process. These are the two domains of the model proposed in section 4.

The proposed model for knowledge management in project management organisations was compared to the model that is used by Sasol Technology. A summary of this comparison can be found in section 7.

Conclusions were reached regarding the extent to which the aims of this study were reached. A discussion of these conclusions can be found in section 8. In section 9 recommendations are made on how to use this thesis and on topics for further research in the field of knowledge management.

2. THE BACKGROUND AND CURRENT STATE OF KNOWLEDGE MANAGEMENT

In this section the reasons for the emergence of the field of knowledge management is reviewed. Knowledge management is also closely related to the shift from an industrial economy to what is referred to by various authors as the "*knowledge economy*" (Clarke, 2001).

The importance and role of knowledge management in organisations and specifically project organisations were investigated. The aim of this chapter is to provide an overview of the most relevant literature on knowledge management, and to summarise the most relevant information pertaining to this text.

2.1 THE EMERGENCE OF THE KNOWLEDGE ECONOMY

In the industrial age, successful companies depended on the three production factors of land, labour and assets for their success. During this era the potential of a company to succeed was reflected in the financial statements, and these statements showed the value and cost of these factors of production. Financial statements, however, are only a reflection of the tangible assets in an organisation.

In the last decade there has been a trend in the electronics and software industries that is in conflict with the assumptions of the industrial age. This growing trend shows that the market value of a company is not only dependent on its book value. An example of this is the market price to book value ratio of the Microsoft Corporation (knowledge age) at 8.8:1 for the quarter ending may 2001, compared to a ratio of 1.1:1 for General Motors (industrial age). The large difference in the ratio can be attributed to Microsoft having more intellectual capital than General Motors does (Matlack, 2001).

This is an indication that the most important production factors in the knowledge economy are no longer land, labour and assets, but rather the knowledge potential of the organisation.

The knowledge revolution, or the shift from an industrial economy to a knowledge economy, is immediately evident if a study is made of the Fortune 1000 companies. For the year 2000 about 57 % of the profit from the top 1000 companies was made in

the 25 industries related to technology, media and financial services (Huey, John 2001, p. F-52). These companies were selling products or services that are derived from the knowledge in their organisations and making a very good profit from it.

Organisations in the high technology sector are not the only organisations that are moving towards the management of knowledge. Almost all of the largest corporations in all sectors are launching initiatives to better manage the corporate knowledge. A recent survey by KPMG (1998) showed that 64% of respondents indicated that they have implemented a knowledge management initiative, or were preparing to implement one (van de Ven, 1998).

These companies are agreeing with the pioneers of this field such as Karl-Erik Sveiby, Tom Davenport, Laurence Prusak and Karl M. Wiig that the effective use of all organisational knowledge is one of the most important competitive advantages that a company can use in the global marketplace.

2.2 THE REASONS WHY THE MANAGEMENT OF KNOWLEDGE IS NECESSARY IN ORGANISATIONS

The argument that an organisation in the knowledge economy needs to manage knowledge to gain a competitive advantage was made in the previous section, while the reasons why knowledge management is necessary are discussed below. First, the need for knowledge management in all organisations in the knowledge economy is discussed followed by a discussion of project management organisations in particular and why knowledge management is of even greater importance in these types of organisations.

The following reasons were sourced from two books *viz.*: **Working Knowledge: how organisations manage what they know**, (Davenport and Prusak 1998) and **Knowledge in Organisations** (Prusak, 1997).

a) Globalisation of companies

More organisations are competing in a global economy. These organisations are geographically spread over different countries and they must co-operate with partners spread all over the globe. The move towards this situation is called globalisation.

The challenges for organisations committed to globalisation are not only a greater distance between physical locations, but also a larger diversity of cultures that need to collaborate. These challenges will result in an increasing demand for concentrated knowledge.

Globalisation will mean that global or geographically dispersed organisations need to enable their members to share and extract knowledge from other people or sources of knowledge that are physically or culturally far removed from them. The result is that people will have to share knowledge with strangers in other countries in order to achieve a common goal.

In many service organisations that depend on experts to deliver knowledge-based services, it has become impossible to have all the experts in one office or even one country. Knowledge management however should enable these organisations to extract the expert knowledge from remote experts throughout the organisation to better service their customers.

b) The search for a sustainable advantage

The ability of a company to learn, innovate, and create knowledge faster than the competition may be the only source of sustainable competitive advantage available in the knowledge economy. More importantly, however, is the ability to transform knowledge through actions and decisions into value for a customer. A true source of competitive advantage cannot easily be copied, as it is the combination of the knowledge embodied in the individual members of the organisation and the application of this combined knowledge.

Organisations will have to use the knowledge potential of all its members to respond faster to market trends than their competitors.

c) The trend towards leaner organisations

In an effort to cut costs a popular approach was for organisations to downsize their workforce. This short-sighted approach, however, soon resulted in a decrease in innovation. By downsizing to a lean organisation, members with experience and knowledge, who were outside the political or managerial sphere of power, were lost. The impact of this loss of human capital was only felt sometime after downsizing and consequently prompted organisations (i) to better manage their knowledge assets,

and (ii) to better understand the connection between the knowledge that is resident in people, and the competitive advantage of the organisation.

d) An increasing complexity of products and processes

Products and services have increased in complexity over the last decade. The knowledge that is necessary to supply these products and services need to be managed effectively in order to succeed in the knowledge economy. The effective management of knowledge and information can decrease this complexity by empowering employees to deal with this complexity.

e) A growing reservoir of both technical and non-technical knowledge

The amount of knowledge and information that is accessible to people can easily lead to information overload and confusion, e.g. people are easily discouraged from using the Internet because the amount of information available is too great. Likewise, the vast amount of corporate knowledge and information in an organisation that is accessible via computer networks can easily confuse and discourage members from using it properly.

Effective knowledge management can ensure that organisation members are exposed only to the relevant information and knowledge.

f) Organisations are employing a more flexible workforce

Companies today are employing a more flexible workforce, e.g. non-core business is outsourced to contractors, and consultants are hired to perform once-off projects or studies. Employee turnover and the employment of temporary staff have also increased with a move away from lifetime employment.

With all these changes in the workforce, it is important to manage the transfer of knowledge from individual employees to the organisation as a whole, as the long-term continuity of the organisation is dependent upon successful and sustainable knowledge transfer.

g) Mobilise, reward and develop people in new ways

The knowledge worker in the knowledge economy will be utilised to the greatest effect in an environment where the transfer of knowledge is encouraged by corporate

culture. In order to attract the most knowledgeable people, organisations will have to create an environment that appeals to professionals.

Knowledge workers will need more than financial rewards to be attracted and retained in an organisation (Ullrich, 1998). The culture of the organisation must be one that values knowledge and the use of knowledge, and this must be reflected in the system of rewards.

This can only be achieved by rewarding members that share knowledge and by informing members of the disadvantage of knowledge hoarding. The performance management and rewards system of an organisation must therefore be suited to the needs of knowledge workers.

h) Customers are empowered by the Internet

The adoption of new technologies like the Internet has given customers access to more comprehensive sources of product information. Through the use of these technologies, customers have become empowered to be more critical in making buying decisions. The customer therefore has more power in the supplier/consumer relationship as a result of a wider knowledge of the market and the products offered in the marketplace.

This development has forced many organisations away from a conventional sales and production orientation towards a marketing orientation. It is no longer sufficient just to produce large volumes of products and sell it on a cost advantage, or develop a product and convince the customers, through hard selling, that they need it, organisations also need to understand the needs of their customers. Organisations can thus deliver products or services that can satisfy these customer needs better than the products or services from their competitors. Marketing and product knowledge need to be accessible to everyone in the organisation in order to be customer focused.

i) Product and service convergence

The shift from a manufacturing-based economy to a service-based economy has made knowledge the key component to the success of most companies. The application of knowledge to satisfy customer needs is the product being sold in service industries. In these service-based industries, knowledge and the application

of knowledge become the most important differentiating factors. Organisations must use knowledge to increase the perceived value of the service provided to customers. Perceived value is the value that customers are willing to pay for.

The fact that service industries generated more than 37% of the revenue for companies on the Fortune 1000 list for the year 2000 (Huey, 2001, p. F-52) indicates that service organisations are becoming a very large part of the economy.

j) Stop re-inventing the wheel

Knowledge management can have a very large impact on cost and time saving by preventing people from repeating the same knowledge creating activities. All the accumulated knowledge of the organisation should be available to all members of the organisation. This will ensure that knowledge is created only once, and only adjusted to fit specific applications from there on. The "re-creation" of existing knowledge in the organisation is a waste of organisational resources, unless it is required to build competency.

Knowledge management can therefore become a driver for innovation, as current organisational knowledge is incrementally improved and applied to increase the competitive advantage of the organisation.

The foregoing are some of the most important reasons why knowledge management is of great importance to all organisations in the knowledge economy. In certain industries the successful use of knowledge will not only give an organisation a competitive advantage, but it is a prerequisite for economic survival.

2.3 THE REASONS WHY THE MANAGEMENT OF KNOWLEDGE IS NECESSARY IN PROJECT MANAGEMENT ORGANISATIONS

For project management organisations that compete in the knowledge economy there are even more reasons to make use of and manage knowledge. These organisations are under the same pressures and are faced with the same challenges discussed above. Some of the additional reasons for knowledge management in project organisations are listed below.

a) The unique nature of project management activities

Projects consist of activities that result in unique and non-repetitive outcomes. The uniqueness of the outcomes or products is a great driver for knowledge management. In other organisation types a product or service can be refined through iteration, whereas in projects there is only one opportunity to deliver a unique result. Using the knowledge of others that have been in similar situations can therefore decrease the risk of failure.

b) Project management across borders

An increase in multi-discipline, multi-department, multi-company, and multi-national projects has forced project managers and project members to use communication technologies and to distribute knowledge on a much wider scale.

In addition, the emergence of virtual teams and video conferencing will change the face of project management as far as meetings and relationships built on face-to-face communications are concerned.

c) Poor cross fertilisation of knowledge

A distinct feature of project teams is that they work almost exclusively as isolated units, and the knowledge gained by a project team is therefore seldom transferred to other teams. This is a driver for deliberate knowledge management in project teams to ensure that the transfer of knowledge across functional, departmental and project boundaries does occur.

d) Risk involved in project management

Projects are usually associated with large capital expenditures and thus great focus is placed on managing financial risk. This risk is normally associated with uncertainty. Projects with great uncertainty in the outcome will be classified as a high financial risk, and *vice versa*. Knowledge management could reduce the risk involved with the management of a project by decreasing the uncertainty, e.g. through greater knowledge of the subject and lessons learned on other similar projects.

From this section, it is evident that all organisations in the knowledge economy have a need for effective management of knowledge. Project management organisations

in particular, owing to their unique and temporary nature, have an even greater need for knowledge management.

2.4 THE DEFINITION AND CONTEXT OF KNOWLEDGE

A proper discussion of knowledge management should begin with the establishment of a working definition of knowledge. To define knowledge in such a way as to study the management of knowledge, it is worthwhile to look at the difference between terms such as science, experience, data, information and knowledge. In this section the differentiating properties of knowledge is discussed, and knowledge is placed in context to management effectiveness.

2.4.1 A DEFINITION OF KNOWLEDGE

A definition of knowledge will only be possible if the different categories of knowledge are understood. According to Michael J. Earl (Prusak 1997, p.5) "*we can posit three levels of knowledge: science ... , judgement... and experience...*" and he proposed two models, *viz.* a hierarchy of knowledge, and a model that describes the difference between data, information and knowledge. These two models are described in more detail below.

Model 1: Hierarchy of knowledge

The levels in the hierarchy represent a decrease in the amount of structure, certainty, and validation. The value of knowledge also increases from accepted knowledge or science to potential knowledge or experience. Potential knowledge of value can hold its value for longer than similar accepted knowledge.

i. Science

Science can be described as the published and tested definitions, facts and theorems available from textbooks, reference books and journals. This can be categorised as accepted knowledge, as the wider scientific community accepts it as true.

ii. Judgement

Judgement is more private, local and idiosyncratic. These can be rules of thumb, the process of assimilation and cultivation of patterns; the frameworks for reference, and educated guesses that help experts perform their tasks. These techniques are

scientifically based, but are more specific in application. This is also referred to as workable knowledge, as it makes science more practical.

iii. Experience

Experience can be described as untapped knowledge and can be current, continually updated, and situation-specific. Experience is a store of historic interactions that can be used to solve current problems and can therefore be called potential knowledge.

Model 2: Knowledge transformation

This model focuses on the process of transformation from data to knowledge as presented in Figure 1 (Prusak 1997, p.7).

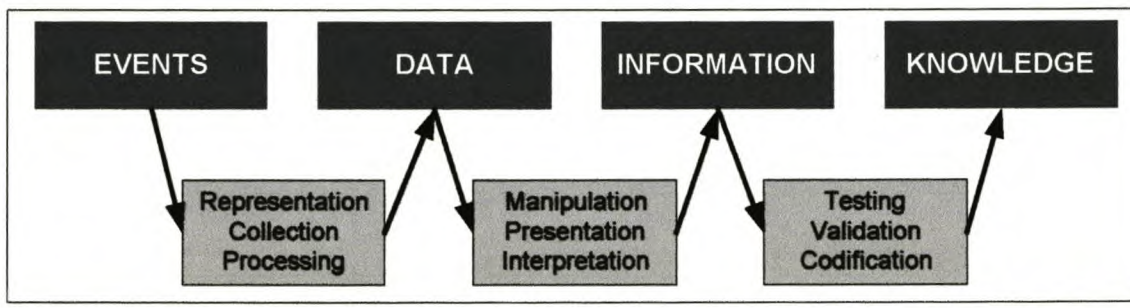

Figure 1 Model of transformation from data to knowledge

i. Events

Events in processes or organisations produce data describing these events. This is the first level of transforming the physical environment into the informational environment.

ii. Data

In **Working Knowledge** (1998, p.2), Laurence Prusak and Thomas Davenport define data as "*a set of discrete, objective facts about events*". This ties in with the model proposed by Michael J. Earl (Prusak 1997, p.6) where data is described as structured records of transactions, and is usually stored in some form of technology system.

It is also a widely accepted fact that more data is not always better. It could become harder to identify the most relevant data when too much data is available. The other reason is that there is fundamentally no inherent meaning in data.

iii. Information

Peter Drucker was quoted as saying that information is "*data endowed with relevance and purpose*" (Davenport and Prusak 1998, p.2). This means that information is data that has been transformed to convey a specific meaning to someone else, and moreover, information can be distributed in a format that will transfer meaning.

Some of the ways to add value to data and turn it into information are (Davenport & Prusak 1998, p.4):

- Contextualise the data. To know for what purpose the data was gathered.
- Categorise the data. To know the units of analysis or key components of the data.
- Calculate the data. The data may be analysed mathematically or statistically.
- Correct the data. Errors can be removed from the data.
- Condense the data. The data may be summarised in a more concise form.

iv. Knowledge

Davenport and Prusak (1998, p.5) presented the following broad description of knowledge.

"*Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of the knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices and norms.*"

Although this definition provides a good starting point for discussion, the definition by Jim Fitchett (1998, p.58) is shorter and more powerful because it gives an indication that knowledge should be acted upon, and that it transforms data and information.

"*Knowledge is the capacity to act on information derived from strategy and the marketplace.*"

Both these definitions however stress the important point that knowledge is derived from information, and that it must be used or acted upon to gain advantage.

The importance of knowledge beyond that of information can further be found in this quote from Herbert Simon: "*In a world where attention is a major scarce resource, information may be an expensive luxury, for it may turn our attention from what is important to what is unimportant*" (Demarest 1997, p.386).

The following points could describe the ways that knowledge is derived from information. (Davenport and Prusak 1998, p.6)

- Comparison. How does information about this situation compare to other situations that we have known?
- Consequences. What implications does the information have for decisions and actions?
- Connections. How do this information relate to other information?
- Conversations. What do other people think about this information?

Tangible or explicit knowledge is knowledge that has already been captured and recorded in some form and can be easily shared. Intangible knowledge (sometimes called tacit knowledge), or know-how, is what we know, but have not recorded or cannot record in a meaningful way. This knowledge is as important as tangible knowledge, but because tacit knowledge is embedded in people, it is much harder to capture and distribute.

With the two structures that were discussed above an attempt was made to provide the reader with an understanding of what knowledge is. For the purpose of knowledge management it is important to know that knowledge is different from information, and knowledge is needed to turn information into action.

The model of transformation proposed by Earl describes knowledge as the highest level of summarisation. Roberts J. Thierauf (1999, p.6) describes the levels of summarisation as data, information, knowledge, wisdom and truth with the levels wisdom and truth positioned beyond knowledge.

"*Wisdom is the ability to judge soundly. Wisdom requires the intuitive ability, born of experience, to look beyond the apparent situation to recognise exceptional factors and anticipate unusual outcomes*" (Thierauf 1999, p.9). This definition states that experience and intuition are needed to have wisdom. This is therefore a needed ability, but one that is not easily transferred or managed.

Truth is the highest level in the hierarchy and is the conformance to fact or reality. Certain truths centred on ethical and environmental issues are useful to managers for guidance and direction.

These last two levels of summarisation are very vague and difficult to define or classify. These are also internal to an individual and cannot be transformed to structural knowledge. This study will concentrate on knowledge as defined in the previous section.

2.4.2 RELATING KNOWLEDGE TO MANAGEMENT EFFECTIVENESS

The previous two models placed knowledge in context with data and information from the viewpoint of the attributes of knowledge. In this section, however, the use of knowledge in management and decision-making is placed in context with data and information.

It is the view of this author that management effectiveness is strongly dependent on timing, e.g. the best strategy implemented too early or too late is of very little use to the organisation. Preventative, or proactive management, is therefore preferred to the reactive, or "fire fighting", approach to management. The author feels that reactive management is often the result of poor communication of information. A manager that is not informed of changes in the environment has little chance of affecting changes in time to prevent losses. All members of the organisation must communicate changes in the internal and external environment of the organisation. This will enable managers to decide on corrective action and ensure the future performance of the organisation.

Marketing personnel will most often discover changes in the competitive environment, whereas operations personnel will discover changes in process performance or raw material quality.

Decision-makers need this information to proactively put strategies in place that will decrease the impact of these changes on the profitability of the company. Sharing of knowledge and information on the environment will enable decision-makers to reduce the risk associated with decisions, by reducing the uncertainty surrounding the decision.

Decision-makers with access to knowledge of all the environmental factors are in a better position to make the correct decisions and steer the organisation. Thierauf confirms the argument (1999, p. 43) as depicted in Figure 2.

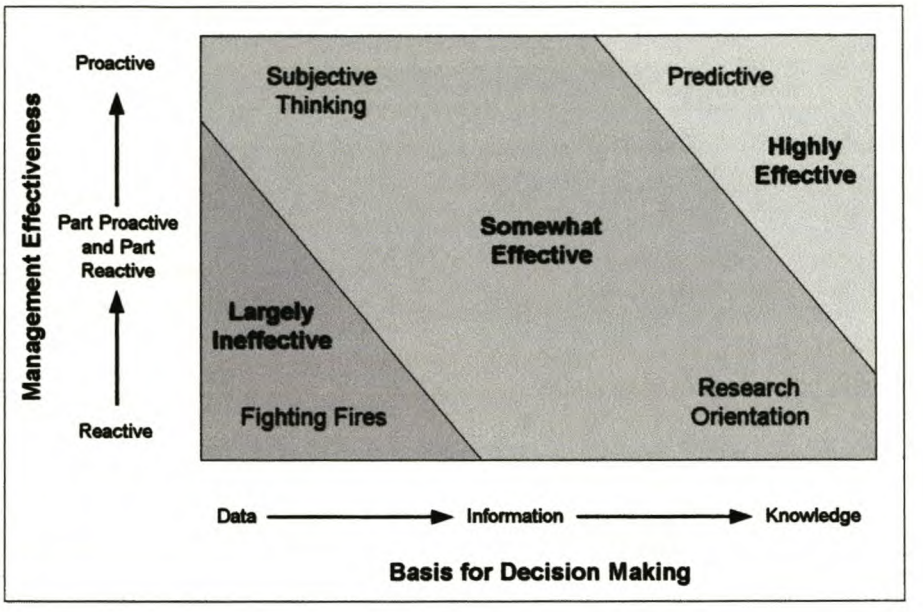

Figure 2 Management effectiveness related to knowledge

Knowledge is used for decision-making in the proactive region, whereas data (historical) and information are used predominantly in the reactive region. Highly effective managers base decisions on knowledge, whereas ineffective managers base decisions on historic data (Thierauf, 1999). From this it can be deduced that the effectiveness of management can be increased by becoming more proactive, while at the same time it is required to base decisions on knowledge and not on information or data.

This increase in management effectiveness can be achieved when managers have access to the relevant knowledge.

2.5 THE DEFINITION AND STRUCTURE OF KNOWLEDGE MANAGEMENT

Knowledge management is an emerging field of study, and for this reason, no generally accepted definitions have been agreed upon to date. The following definitions will be used to provide the reader with an understanding of what knowledge management is.

"*Knowledge management is an emerging set of organisational design and operational principles, processes, organisational structures, applications and technologies that helps knowledge workers dramatically leverage their creativity and ability to deliver business value*" (Gurteen 1998, p. 6).

From this definition it is clear that the focus is on parts of an organisation that must be managed to ensure that knowledge workers can deliver value through creativity.

"*Knowledge management is the process of continually managing knowledge of all kinds to meet existing and emerging needs, identify and exploit existing and acquired knowledge assets and to develop new opportunities*" (Demarest 1997, p. 387).

In this definition the focus is on the use of and creation of knowledge assets to fulfil organisational needs.

"*It's about using information strategically to achieve one's business objectives. Knowledge management is the organizational activity creating the social environment and technical infrastructure so that knowledge can be accessed, shared and created*".

The definition by Robert K. Logan stresses the point that an environment must be created within the organisation that is conducive to knowledge creation, distribution and use. From the three definitions above it is evident that knowledge management is concerned with organisational design and creating an environment within the organisation that promotes the creation and use of knowledge to fulfil organisational needs.

From the literature, several models were found to describe knowledge management in general. The models were considered to be too generic to apply to any specific industry, or sector in an industry without adapting and refining it.

In this chapter a general knowledge management model was constructed from literature sources. Having obtained this model it was then used as the basis for the development of a model that is specific to and applicable to a project management organisation.

The models encountered in the literature distinguish between the knowledge management process and knowledge management enablers and the knowledge management processes used by the different sources are presented in Table 1.

The processes summarised in Table 1 consist of sequential steps. The enablers are needed to ensure the process is effective, and therefore used to the advantage of the organisation. The enablers will be the foundation on which the knowledge management process is implemented.

Table 1 The knowledge management process by different sources

Source	Davenport (1999)	Finerty (1997) Arthur Andersen	Stephens, Kasher, et al. (1999)	Siboni (1997) KPMG Peat Marwick
Step 1	Create	Create	Identification	Acquisition
Step 2	Capture/store	Identify	Adaptation	Indexing
Step 3	Refine	Collect	Documentation	Filtering
Step 4	Distribute	Adapt	Publicity	Linking
Step 5	Use	Organise	Adoption	Distribution
Step 6	Monitor	Apply	Measurement	Application
Step 7		Share		

The knowledge management model proposed by Tom Davenport (1999) has three enablers; *viz.* technology, process and people. Davenport includes the process as an enabler. The model used by Arthur Andersen (Finerty, 1997) in the Knowledge Management Assessment Tool has four enablers, *viz.* leadership, culture, technology and measurement. Arthur Andersen refers to the two domains as the hard (process) and soft (enablers) domains.

Although the enablers and process steps differ between organisations and authors the following general model for knowledge management in organisations was compiled by the author from the above models summarised in Table 1.

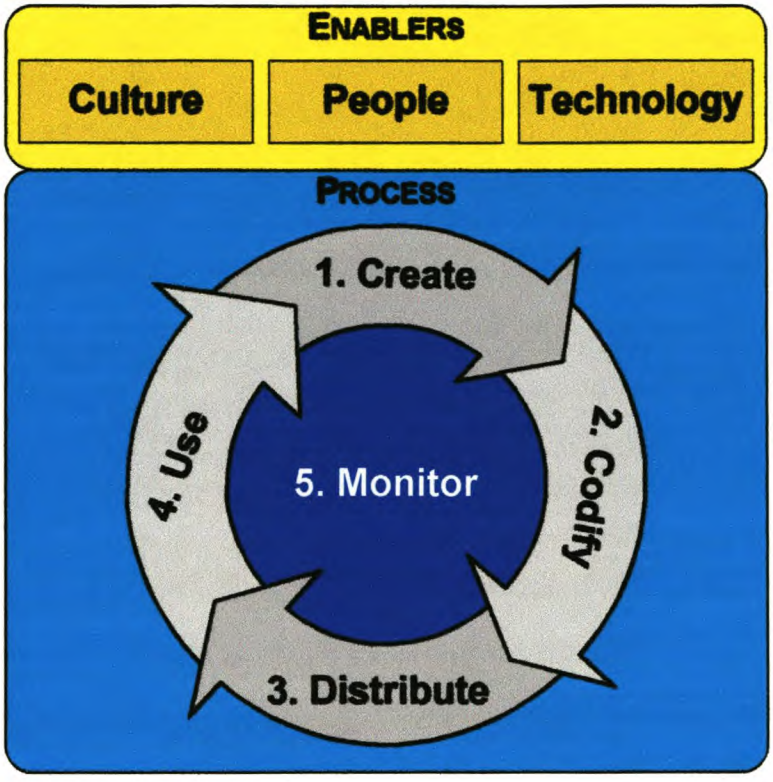

Figure 3 Compiled general knowledge management model

This model was used as a starting point for the development of the knowledge management model for project management organisations. The model in Figure 3 was also used in discussions with experts and project managers. The components of the general model presented in Figure 3 will briefly be described in the following paragraphs.

2.5.1 THE GENERAL KNOWLEDGE MANAGEMENT ENABLERS

Three knowledge management enablers were selected from the ones found in the literature. Knowledge-focused culture, people and technology are the enablers that will be used in this model. These enablers will be briefly discussed below.

a) Knowledge-focused culture

This component addresses all the organisational cultural and leadership structures that are necessary in an organisation to implement a successful company-wide knowledge management system.

This enabler is of primary importance as it ultimately determines the success or failure of a knowledge management initiative (Davenport, De Long and Beers, 1998). An organisational culture focussed on knowledge sharing and learning will make people approachable with new ideas. This enabler will not only enhance the operation of the knowledge management system, but is also of importance for the implementation of the initiative. It is also noteworthy that organisational culture is the enabler that is most difficult to change or manage.

b) People in knowledge management

Knowledge management must be implemented throughout an organisation to ensure the success of the initiative. A dedicated group must pilot and lead the change program, but after successful implementation, knowledge management becomes the responsibility of every employee. Although the responsibility for the administration and future development of the system should remain with a few dedicated employees, all the members of an organisation should participate and share knowledge if the performance of the organisation is to be enhanced.

Knowledge workers deliver knowledge as a product and do not directly contribute to the production of physical products. These employees must be handled different from other workers. Although all members of an organisation use knowledge to perform their work, managers must be able to bring out the best in knowledge workers, and develop their full potential. The skills needed to ensure successful knowledge management must be identified and developed in all members of the organisation. People, together with the knowledge-focused culture are the primary drivers for successful knowledge management. Technology is used in knowledge management to automate the knowledge management process and to connect people.

c) Technology in knowledge management

The difference between knowledge management and information management is highlighted by the use of technology. Information is easily captured and transferred using information technology. Technology is primarily used in knowledge management to connect people to others that have relevant knowledge.

The technologies that can be useful for knowledge management must be identified, in particular those technologies that can be used to integrate knowledge management and enhance communication in projects. It is important to realise that technology is only considered to be a secondary enabler and must not be used to drive the knowledge management initiative.

2.5.2 THE GENERAL KNOWLEDGE MANAGEMENT PROCESS

The knowledge management process consists of five components that will ensure the effective management of knowledge. The enablers described in the previous section must support the process that is described below.

a) Knowledge creation

Knowledge is generated when information is absorbed from the internal and external environment and turned into knowledge to be acted upon. This is done in two distinct ways. Firstly, new knowledge can be developed, which is called creativity. The other means of knowledge creation is the combination of previously developed knowledge. This is called innovation and can lead to new knowledge or new applications of existing knowledge.

b) Knowledge codification

Knowledge codification is the act of turning knowledge into a form that can be accessed by all the people that need it. The purpose is to make knowledge as explicit, organised, portable and as easy to understand and apply as possible.

The process of transforming tacit knowledge into explicit knowledge, or information and the storage of that information, is called codification. This also includes the mapping of knowledge sources embedded in people and that cannot be transformed.

c) Knowledge distribution

The distribution of knowledge can be done according to two modes. Active distribution sends information and knowledge sources to the relevant people that need the knowledge or information. Passive distribution is done when people search for knowledge and it is then transferred to them. The person that needs the knowledge must initiate the search for the knowledge.

Depending on the situation, a combination of the two modes makes for proper distribution of knowledge.

d) Knowledge use

Acting on or applying knowledge can transform it into a competitive advantage for the organisation. This will result in better-informed decisions with a decrease in the risk associated with these decisions. People in organisations must therefore be motivated at certain points in the work process to search and use knowledge generated earlier.

Organisation members will use the available knowledge in their work if it can be of advantage to them, or if they are motivated to act in the best interest of the organisation.

e) Knowledge monitoring

The monitoring of knowledge provides a feedback function that enables the users of knowledge to change and improve the corporate knowledge base. This function should be performed by dedicated experts, which are in a position to evaluate the relevance of specific knowledge objects. Monitoring also gives feedback to the implementers on the effectiveness of the knowledge management process.

This general model that was developed by combining components from the literature consists of knowledge management enabler and a knowledge management process. The three enablers are: a knowledge-focused culture, people and technology. The knowledge management process consists of five steps: *viz.* knowledge creation, knowledge codification, knowledge distribution, knowledge use, and knowledge monitoring. This model will be refined to be used specifically in project management organisations.

3. THE BACKGROUND AND CURRENT STATE OF PROJECT MANAGEMENT

In this section the field of project management is discussed. A literature study of project management provided facts on the background and definitions of terms used in the field. Interviews with project managers along with the literature study were used to determine the reasons for poor performance in projects.

3.1 THE EMERGENCE OF THE FIELD OF PROJECT MANAGEMENT

The field of project management as we know it today was established during the 1950's and 1960's by the US defence and aerospace industries. The construction industry also added some of the tools that are still used today. In 1969 the Project Management Institute (PMI) was formed and **A Guide to the Project Management Body of Knowledge** (PMBOK) was first published in 1987.

The Project Management Institute uses the following definition of a project in the PMBOK.

"*A project is a temporary endeavour undertaken to create a unique product or service. Temporary means every project has a definite beginning and end. Unique means that the product or service is different in some distinguishing way from similar products or services*" (PMI 1996, p. 4).

The following definition of project management will be used in this text to refer to the field of study of projects and the project management process:

"*Project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project*" (PMI 1996, p. 6).

The term project management organisation will be used in this text to refer to organisations that use the management-by-projects concept to manage key initiatives. Project management organisations use project management as the preferred way of management, and most of the resources in such organisations are involved with projects.

Organisations are "...*consciously co-ordinated social entities in modern society, with relatively identifiable boundaries, that function on a relatively continuous basis to achieve specific goals*" (Swanepoel et. al 2000, p. 4). In this document, an organisation is defined as a group of individuals that work within a structure towards a goal. For business enterprises such as companies, the goal is to make a profit and for charities the goal is to serve society.

This study will not only focus on the needs of commercial companies that have a profit motive, but will investigate the use of knowledge management in all organisations that use project management.

The last definition needed in order to discuss project management organisations, is the project management process.

"*A process is a series of actions that bring about a result. (The) project management process is concerned with describing and organising the activities of a project*" (PMI 1996, p.27). The term project management process will be used throughout this thesis to describe the general process, tools and techniques used in managing projects.

Figure 4 The project management life cycle

The project management process comprises a project life cycle and a process within each of the life cycle phases. The project life cycle phases used in this study are shown in Figure 4 and were compiled from interviews and the literature. Details of this literature review are presented in Appendix B of this document.

The project management process as described in the project management framework, **A Guide to the Project Management Body of Knowledge** or the **PMBOK Guide** as it is better known (PMI 1996, p.29) is presented in Figure 5. The process is comprised of five process steps, and the process is found in each phase of the project life cycle. The knowledge management model must support these processes in each of the life cycle phases.

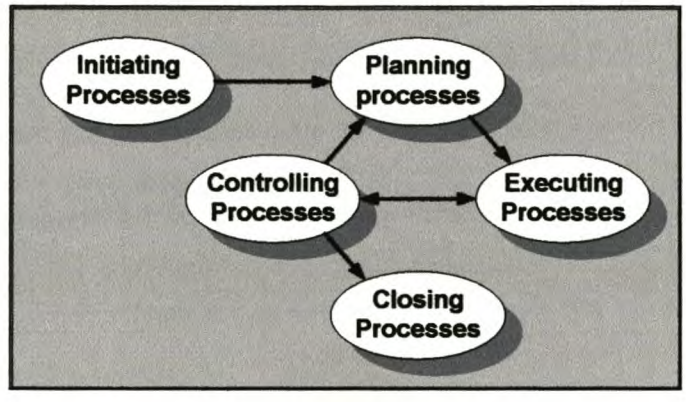

Figure 5 The project management process

In each phase of the project lifecycle, the knowledge management process will be used in conjunction and in support of the project management process.

The formalisation of the project management process has led to project managers overemphasising the importance of documentation. This documentation is an effort to distribute and store project information. The reasoning is that thorough documentation will ensure thorough project management.

Project managers agree that these documents are seldom used in future projects and are usually not easily accessible. The large amounts of information captured in documents usually become a hindrance more than help because the volume discourages prospective users.

Most project managers agree that the most useful knowledge is based on heuristics and is stored in the heads of people. This is the knowledge that must be utilised in order to ensure effective project management.

3.2 THE TYPICAL REASONS FOR POOR PROJECT PERFORMANCE

The project areas that could benefit from knowledge management were identified by interviewing project managers and by a literature study of project case studies. During the interviews and literature review the emphasis was on finding the project management life cycle phases where knowledge management can make the greatest contribution towards project success. The project life cycle phases that are presented in Figure 4 were used as reference during these interviews.

Deviations from the plan for cost, time and quality of the outcomes of the project are deemed as signs of poor project performance. Projects that perform poorly can therefore be identified as projects that deviate from the budget, schedule or scope. Reasons for these deviations from the budget, schedule or scope of the project are seen as the causes of poor performance in projects.

The areas of project management that leads to poor performance in projects were identified from literature and interviews. These are areas that might be improved with the use of knowledge management. These areas were sometimes not described by the project life cycle phases, or were covered by more than one phase. The areas of project management where knowledge management can have a direct and positive impact are presented in Table 2 below. The table presents the reasons for poor performance with the corresponding project life cycle phase next to it.

Table 2 Reasons for poor performance of projects

Reason for poor project performance	Project life cycle phase
Poor estimates	Project definition / concept phase
Project end not defined clearly	Project definition / concept phase
Incomplete user requirements	Project definition / concept phase
Too high technology risks	Project definition / concept phase
Risk from unknown variables	Project definition / concept phase
Incorrect contracts	Project feasibility phase
Project priorities not stated	Project feasibility phase
Lack of formalisation	Throughout project
Change in external environment	Throughout project
Poor documentation	Throughout project

A list of the project personnel that were interviewed and the literature that was reviewed are presented in Appendix A. After five interviews the results indicated that the project management areas where knowledge management can have the greatest impact are similar for different project environments.

The results from the interviews were used to produce an Internet based survey to verify the results of the interviews. The PMI-SA (Project Management Institute – South Africa) posted a request for participation with a quarterly electronic newsletter to all members. The PMI-SA has approximately 1300 members, and seven individuals completed the survey form. This is approximately 0.5% of the invited participants. This showed that Internet surveys are a convenient form of data gathering, but because it is more anonymous, it is significantly more difficult to solicit a response.

Even with only the few responses it was decided to use the interview results because they were correlated with the results found in literature on project management.

In Table 2 the areas of concern are shown next to the project management life cycle phase where these areas are most likely to occur. It must be stated that proper knowledge management practices will improve other project management issues not listed here.

The greatest impact on projects can be made at the start of the project. At this stage in the project life cycle the cost of changes to the product of service delivered by the project is relatively small. From Table 2 above it can be seen that the pre-feasibility phase, up to the beginning of development, is very important to project success. From the interviews and literature it was deduced that poor project performance could be prevented, by appropriate action in the early stages of the project. It is also an established fact in project management that the cost of change is relatively low during the early phases of the project life cycle, whereas the impact of change can be significant at this stage.

The knowledge management model that is developed in this study will be designed to improve these areas of project management that lead to poor project performance.

4. A KNOWLEDGE MANAGEMENT MODEL FOR PROJECT MANAGEMENT ORGANISATIONS

A knowledge management model that is applicable to a specific industry or organisation must be developed to take into account the environment and structure of the industry or organisation. The general knowledge management model as proposed in the literature is applied to the project management environment, with particular emphasis on resolving the reasons for poor performance in projects.

The knowledge management model for project management organisations must combine the general knowledge management model with the characteristics of a project management organisation. The characteristics include the project management life cycle and process and the flow of knowledge and information in project management organisations.

4.1 THE FLOW OF KNOWLEDGE IN PROJECT MANAGEMENT ORGANISATIONS

The knowledge management model that is proposed in this study must be integrated with the project management process. In order to integrate the knowledge management model with the project management process, the flow of information and knowledge in project management organisations must be understood.

Knowledge is most often used in organisations to solve problems. All knowledge creation or use starts with a problem or a need. This need is expressed by a client or client group and can be the result of a change in the external environment, for example the marketplace, or due to a change in the internal environment, for example a change in the manufacturing process of a company. It is very seldom and usually in the research and development field, that a new technology or field of knowledge is developed before an application for the knowledge exists. This problem or client need is the driving force for finding a solution. The solution is measured against the problem to determine when the problem solving process is complete.

Borghoff and Pareschi (1998, p. 58) describe problems that need the use of knowledge in order to be solved as "*wicked problems*". These are complex problems as can be seen from the guidelines for identifying "*wicked problems*".

1. Problems are not easily defined and stakeholders cannot easily agree on the specific problem to be solved.
2. Complex judgement is needed on the level of abstraction of the problem definition or problem scope.
3. No clear stopping rules exist for solving the problem, solutions to problems are typically of the better vs. worse type not the right vs. wrong type and no objective measure of successful solving of the problem exist. This means that a problem can be solved by more than one solution.
4. Problem solving requires iteration to reach a solution
5. The alternative solutions to a problem must first be discovered, as they are not given, and a decision must be made to select one or more of the alternative solutions.
6. The solving of a problem involves strong moral, political and professional implications, especially for failure.

The process of solving these wicked or complex problems can be called knowledge work and is done by knowledge workers. From the definitions above it can be seen that almost all work in project organisations is knowledge work, and must therefore be done by knowledge workers.

The nature of such a complex problem can be one of three, a decision that needs to be made, planning that needs to be done, or an exploration of some topic. The tools used to solve these problems vary and are well documented (Brassard and Ritter 1994). The overall method of incremental problem solving, as presented in Figure 6, applies to all complex problems. Complex problems are usually broken down into smaller parts. Solutions are found for these parts in order to solve the complex problem.

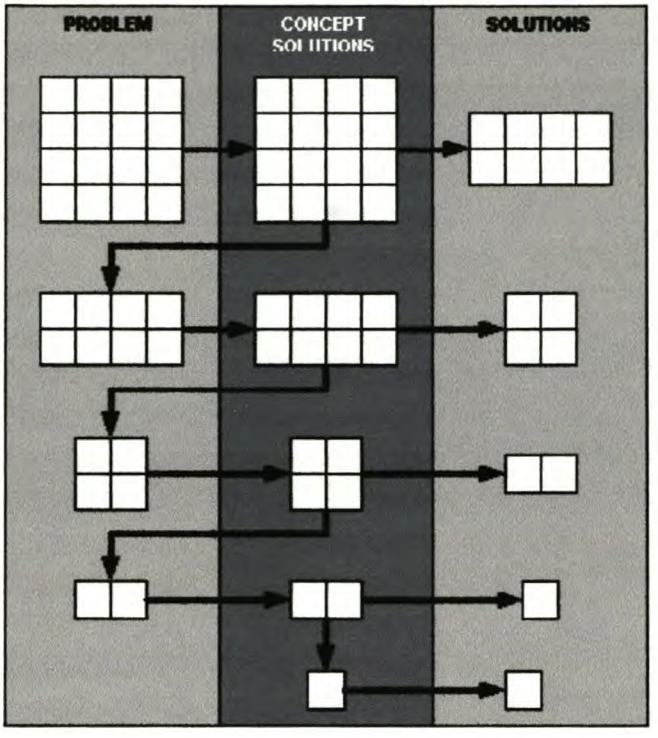

Figure 6 Incremental problem solving

The first attempt to find solutions will result in a number of concept solutions. These are alternative options, and the most appropriate solution must be selected. This will more often than not lead to more problems to be solved. Concept solutions are now found for the sub-problems and the appropriate solutions are selected. In this way the resulting sub-problems are solved until all problems are solved, or the risk associated with the remaining problems are acceptable to all involved.

In projects a group of people are involved in this process. The use of knowledge to solve problems using this incremental process is also used in project organisations. The flow of information and knowledge in a project organisation with a matrix structure is shown in Figure 7 below. This figure will be used to illustrate how knowledge flows in the project management organisation when problems are solved using incremental problem solving.

The knowledge management model developed in this study must support this process. The correct knowledge must be available to the relevant people at the right moment in order to have successful problem solving capability in the organisation.

Knowledge, information and data are used as inputs in the problem solving process. In Figure 7, it can be seen that resources do all the problem solving. These

resources can be people or people using machines. The distinction between the terms, knowledge, information and data is important in this model. Knowledge can only be exchanged directly between people or be captured in processes or procedures in the organisation. It is therefore essential that a knowledge management system bring people with knowledge together in the knowledge market. The organisational culture must then be conducive to the trade in knowledge. This means that people must be motivated and empowered by a culture of knowledge sharing.

This knowledge can be transformed to information, and can be stored and transmitted in that format. Knowledge that is transformed to information can lose some of its potential, as it is no longer applicable outside the context in which it was captured.

The transformation from tacit knowledge to explicit knowledge and from explicit knowledge to information is called codification. This is a very important step in the knowledge management process. Knowledge that is resident in the heads of people can only be accessed through direct communication, and trust is essential for this exchange of knowledge. Once knowledge is turned into information it can be stored, indexed and distributed more easily.

The exchange of knowledge in a project organisation often crosses over functional and project borders. Strong bureaucratic organisations or matrix organisations with very strong functional groups can involuntarily hinder this exchange. Informal networks are important for knowledge exchange because it can be used to distribute information actively to people with similar interests.

Mapping informal networks of trust, communication and advice will enable management to implement changes by informing the most trusted employees. This will all be described in chapter 6.3 on knowledge distribution.

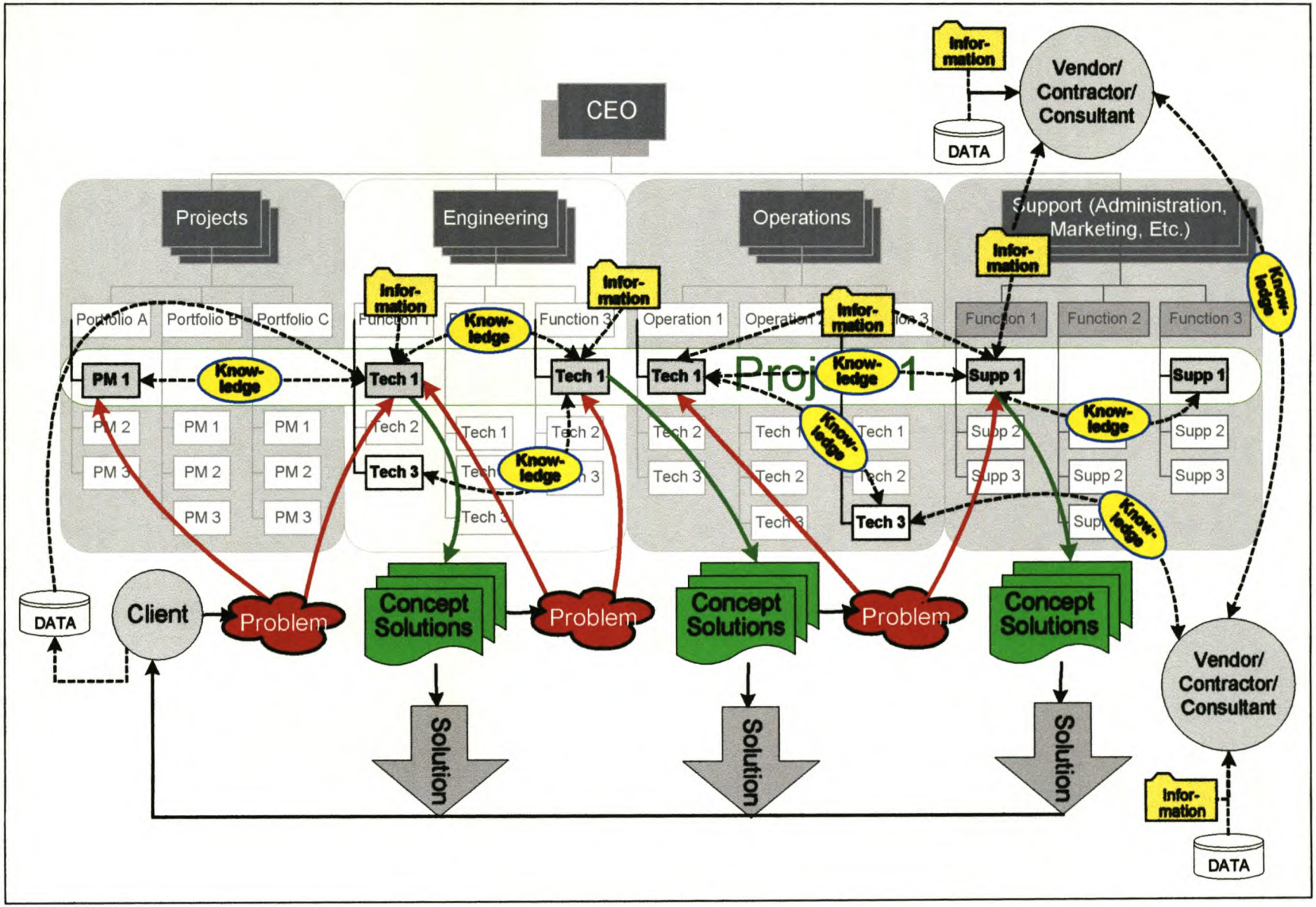

Figure 7 Problem solving using knowledge, information and data

Knowledge that is codified in the form of information must be stored in an easily accessible place and format. The information storage and accessibility can be seen in Figure 7 to be spread out throughout the organisation. This decentralised storage necessitates the flow of information between people. The flow of information between individuals can be limited and efficiency increased with the use of a central information store.

Centralised electronic storage of information will force the focus on technology that can help with the codification, storage and distribution of knowledge and information. The distinction between knowledge and information must always be made. It is also important to note that a good knowledge management initiative can be severely crippled by poor information management.

The model in Figure 7 only looks at the process of knowledge flow through a project organisation. The enablers for this process to work effectively: people, knowledge-focused culture and technology, are however much more important. It is the opinion of the author that the culture of knowledge sharing is not natural to most people. People will often hoard knowledge in an effort to gain power. In organisations where people with expert knowledge are perceived to have power this will prevent others from sharing openly. If the culture of knowledge sharing is not prevalent in the organisation, the network of knowledge contacts illustrated in Figure 7 will not permit knowledge to flow.

People that work in project environments should be used to dynamic environments of authority. The line manager in the functional group has authority over certain matters pertaining to the function, and the project manager of a specific project has authority over matters concerning the project. Some personnel may be involved in different projects at the same time, and in different roles. A person may be the project manager or leader in one project, but only a team member in another project, similarly a manager of a function in the matrix organisation may be a team member in a project. This environment demands a person with specific skills and attributes who can respond flexibly in such circumstances.

During the problem solving process, a great deal of knowledge is and must be transferred to the client. This means that the client can find similar solutions by using

the same knowledge. The knowledge used to generate a successful product or service can thus be used in a similar way to produce further successes.

The flow of knowledge in project organisations and the use of the knowledge for problem solving were illustrated in this section. In the next section the model of knowledge management that will support this flow of knowledge is discussed.

4.2 THE KNOWLEDGE MANAGEMENT MODEL

The general knowledge management model that was derived from the literature is developed in more detail to be applicable to project management organisations. The model for project management organisations is presented in Figure 8. The model consists of the three knowledge management enablers: knowledge-focused culture, people and technology and the five components of the knowledge management process.

This model must support the project management process and project life cycle. Knowledge management must be used in each phase of the life cycle to ensure project success. The knowledge management process is therefore developed to support the project life cycle and the knowledge management enablers must support the knowledge management process.

The first enabler in the model is the knowledge-focused culture. In project organisations different types of cultures are involved. Managers must understand the role that culture and organisational culture play in teams, and they must be able to manage this.

The second knowledge management enabler that is of importance in a project management organisation is the people. In project management organisations it is important to understand the roles of individuals as well as the management of teams. These individuals and teams work within the organisation structure. The organisation structure for project management organisations that is proposed here must integrate the project management roles with the knowledge management roles. This enabler also focuses on the model for team effectiveness and the influence of team effectiveness on knowledge management.

The third knowledge management enabler is technology. Knowledge management technologies must support the knowledge management process and be integrated

into the project management process. The knowledge management process is developed to support the knowledge flow needed for problem solving in project management organisations.

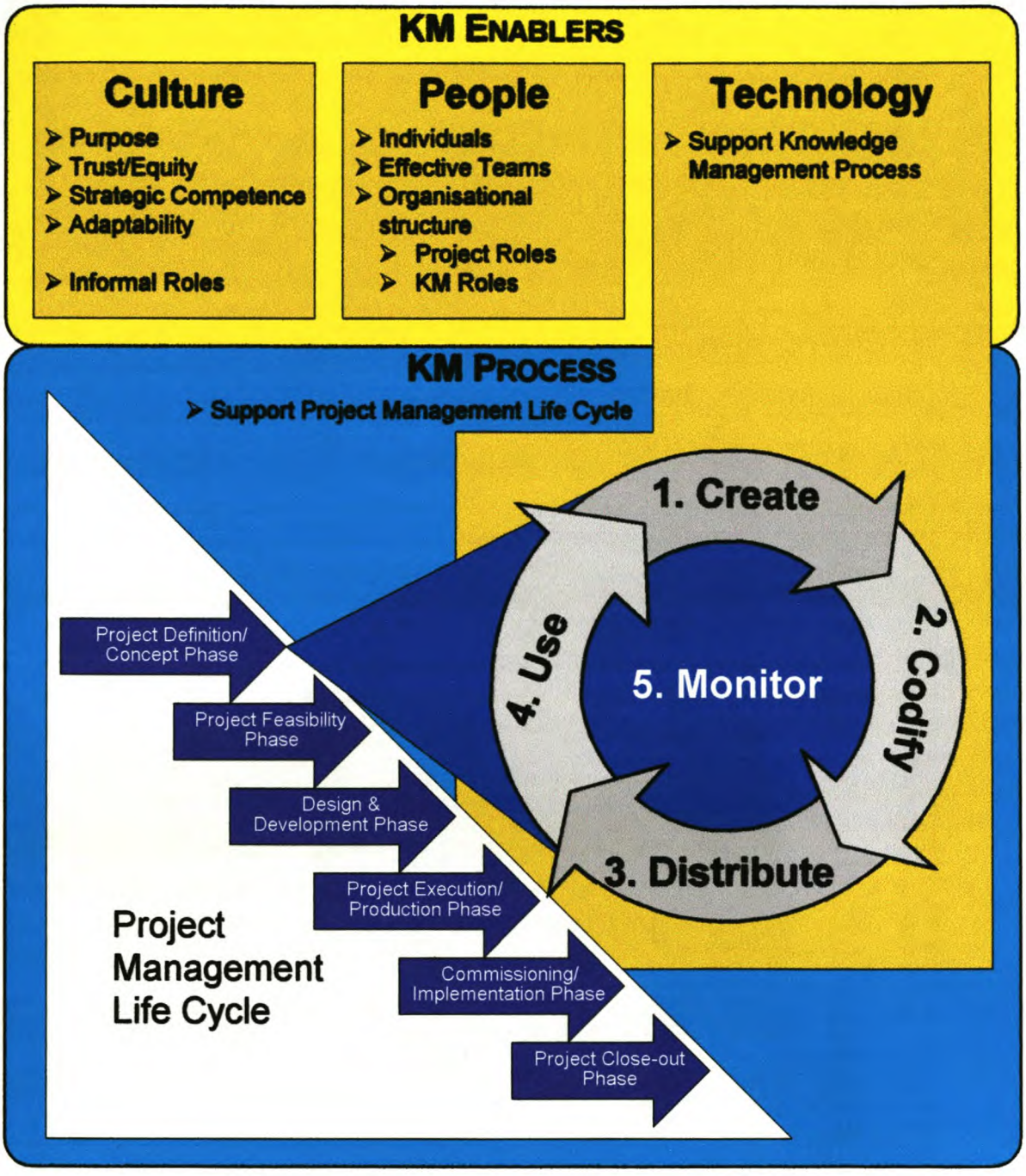

Figure 8 The knowledge management model for project organisations

In the next two sections the knowledge management enablers and the knowledge management process for the knowledge management model for project management organisations will be discussed in detail.

5. KNOWLEDGE MANAGEMENT ENABLERS

This chapter describes the knowledge management enablers for a project management organisation. The enablers are knowledge-focused culture, people and technology. The enablers are important to ensure that a knowledge management initiative is implemented properly.

Of the three enablers, a knowledge-focused culture is the most difficult to implement. A knowledge management initiative will have difficulty to succeed if the knowledge-focused culture is not in place. Hirotaka Takeuchi (1998) states that knowledge management in Japan is embedded in the culture of "*continuous innovation*", and therefore he warns Western managers against an approach that is focussed too much on the process and technology of knowledge management.

Organisations are made up of a collection of individuals that work towards a common goal. To ensure the successful implementation of a knowledge management initiative it is important to focus on the interaction between these individuals, as well as on the people themselves. This interaction will result in the organisation culture, and this culture must be conducive to knowledge sharing.

In this section the organisation culture will be discussed first and then the individual people and teams of people. The third enabler that is needed for successful knowledge management is technology. This is the easiest enabler to implement, and is dependent mostly on an existing information management infrastructure and the availability of funds.

5.1 KNOWLEDGE-FOCUSED CULTURE

In this section the role of organisational culture as an enabler for knowledge management will be discussed. The focus is on project management organisations and on how to shape and use the organisational culture to ensure knowledge sharing is successful.

According to Bristow and Sandberg (1995) organisational culture is defined as follows.

"*Organisational culture consists of the values, beliefs, and norms that manifest themselves in the habitual ways organisation members accomplish their work, relate*

to one another, solve the problems that confront them, and interpret their social surroundings."

From this definition it is evident that individuals in the organisation form the organisational culture through their interaction with others. The organisational culture is also strongly influenced by leadership within an organisation (Sarros, 2001). The organisational culture is therefore an indication of the values, beliefs and norms of the individuals and leaders in the organisation. An initiative such as knowledge management must be aligned with the organisational culture to ensure the individuals in the organisation accept it.

An organisational culture that supports knowledge sharing must exist in the organisation if knowledge management is to be successful. If such a culture does not exist, the organisational culture must be changed to become supportive of knowledge sharing.

In the rest of this chapter, the problems in the organisational cultures of typical project organisations will be discussed. Then the desired organisational culture and the ways to influence the organisational culture in order to change it will then be discussed.

5.1.1 PROBLEMS IN THE ORGANISATIONAL CULTURE OF TYPICAL PROJECT ORGANISATIONS

Project teams are made up of employees from different functions and sometimes from different organisations. This can lead to cultural differences in the project team. An organisational culture is made up of several sub-cultures. The differences in culture are related to the specific discipline or the organisational function from where employees are drawn into the project.

The organisational culture differences between these groups will have an effect on the project team and the culture within the team. The five levels of cultural difference in projects can be summarised as follows.

1. The cultural differences of the functions represented in the project team. The culture of a research and development function differs greatly from the culture of a marketing function. Project team members from the marketing function and

members from research and development must however be united in the single culture of the project to ensure good teamwork and communication.

2. The cultural difference between the group responsible for project management in an organisation and the bureaucratic culture of the line functions. In organisations that use a matrix organisational structure, with project members reporting to functional managers as well as project managers this can lead to problems.

3. The different projects launched in different parts of an organisation can have different cultures, which are associated with the function sponsoring the project. A marketing project will for example have a different organisational culture than an engineering or production project. This is due largely to project managers from a specific function that want to enforce a culture on a diverse group, rather than fostering the development of a unique culture.

4. The organisational culture of partner companies in an alliance project can seriously influence the conflict resolution abilities of the project team. This can cause subgroups to form within the project that will negatively influence the outcome of the project.

5. The final and most difficult cultural issue to address is multi-cultural projects that span the national borders of two or more countries. In these cases, the cultural issues are much wider than the organisations involved, and are more deeply rooted than organisational culture.

All five of these levels can be present in a single project. Project managers should be aware of these cultural differences, in order to create the correct project culture. Terry Cooke-Davis and Eric Wolstenholme (1999) identified three problematic project cultures.

1. A project culture where planning is discouraged and project managers do projects "on the fly" in short time spans is called macho management. This culture encourages employees to use their own limited knowledge instead of planning a project based on the combined knowledge of the project team and the organisation.

2. A culture where estimates are severely influenced by imposed completion dates or restricted resource budgets is called incentive-riddled-estimating. In these cultures top management will only accept estimates that are within the deadlines they set. This will usually result in serious over expenditures and delays because projects are approved on inaccurate estimates. This is a project culture that results in distrust between top management and project members. Project plans and budgets are cut because top management does not trust the employees to prepare realistic and challenging plans. The knowledge used by project planners is therefore discarded.

3. The third culture is the administrative bureaucracy. In this culture the correct process is always followed and the emphasis of the project management is on the process and not the results of the process. Mechanistic project management without much regard for the individual characteristics and needs of team members is a symptom of this culture. This culture discourages learning and innovation in the way a project is managed.

Deal and Kennedy have identified two other types of project cultures in their book **Corporate Cultures** (1982, p. 107).

4. The work hard/play hard culture is focussed on fun and action. This culture encourages employees to maintain a high level of low risk activities. This culture encourages employees to work hard, and not necessarily to work smart.

5. The bet you company culture is based on employees taking high risks and waiting a long time for feedback to measure the success of decisions. Problems and decisions are not broken down into sub-problems, and results are only received after implementation of the most important decisions. The irregular and limited feedback that result from this project culture will limit learning, and prevent team members from applying more appropriate knowledge as more information becomes available.

These cultures are all prohibitive to proper knowledge use in projects. These are however not the only ways to prevent the sharing and use of knowledge in project organisations.

In organisations where downsizing is used as a means of cutting cost, workers may feel that their knowledge is critical to their unique value as an employee. Employees can perceive that the loss of their value through the sharing of knowledge might jeopardise their job security.

In organisations where emphasis is placed on the originality of innovations, this organisational culture can prevent employees from reusing knowledge. The organisational cultures in these organisations discourage combination as a means of creating new knowledge. This is also true for an organisation where the innovative workers are elevated by the culture. This can lead to very slow innovation, as all new products will be designed from first principles, with a disregard for existing ideas.

In organisations where there is distrust between management and employees, the employees will resist the documentation of decisions, for fear of recriminations when decisions turn out to be wrong. This is often the case in an organisation that is not error tolerant. Organisations that document decisions and that are able to learn from them can prevent the repetition of mistakes. The following quote from B Le Platner is a good summation of this (Sveiby 2001). "*A good judgement is achieved through experience and experience is achieved by bad judgement.*"

The next section will discuss the desired organisational culture in project organisations.

5.1.2 DESIRED ORGANISATIONAL CULTURE IN PROJECT ORGANISATIONS

The model of Alan Wilkens of the Brigham Young University (Bristow and Sandberg, 1995) will be used as a framework to discuss the desired project culture for knowledge management. As can be seen in Figure 9 on the next page, the model consists of four elements, *viz.* purpose, strategic competence, trust and equity, and adaptability.

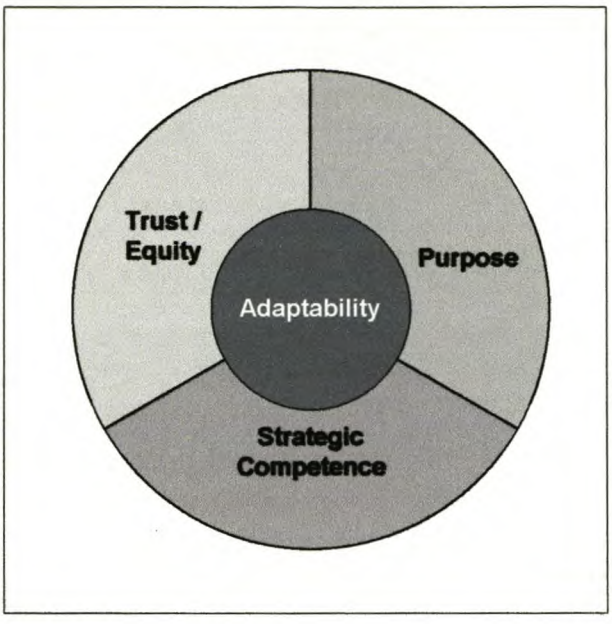

Figure 9 The four elements of organisation culture

The American Productivity & Quality Centre (APQC) conducted a study of organisations that have an organisational culture that supports knowledge sharing. This study found the following characteristics of organisational cultures that support knowledge sharing (McDermott and O'Dell, 2000).

Knowledge sharing is coupled visibly and invisibly to solving practical business problems. Visibly it is defined in the documented values, mission and vision of the organisation. Invisibly it is entrenched in the set of core values that guide people in their interaction with one another. The organisational purpose is defined in the visible manifestations of the organisational culture.

a) Organisational Purpose

A shared sense of purpose provides people with motivation and direction in projects and in the organisation. People are greatly motivated by the basic human need of being important to and belonging to a society. Workers that know their purpose and the contribution they make to projects and the organisation feel useful and are motivated by the feeling of belonging to something worthwhile. This will enhance the loyalty and commitment of employees to the goals of the projects they are involved with.

This shared purpose will also guide workers in their actions and decisions. This can be fostered in the organisation through good communication of the strategic intent of the organisation. The strategic intent is manifested in the documented vision, mission, values and goals of the organisation. When workers are able to link their specific tasks to the goals of the organisation and are guided by the values of the organisation, the sense of purpose will increase. Workers must also understand the importance of tasks performed by others in reaching the organisational goals.

Project team members that understand the importance of others and the contribution they make to the project will be eager to collaborate. Project team members that only understand their own contribution will be more hesitant to share knowledge with others.

The role of the organisational leadership should be to guide change by giving direction and motivating people. When organisational change is in accordance with accepted values, people will embrace it because they have collectively formed the value structure of the organisation.

b) Strategic competence

The strategic competence of the organisation is closely related to the purpose element. Workers that feel they have a purpose must be convinced that the competence of the organisation will make it possible to pursue and reach these goals. This belief is very important if people are to invest themselves in the goals of the organisation.

Management can influence the skills and competence of the organisation through development and training, acquisition or the use of consultants. This means that competency can be made, bought or borrowed. It is however important to raise the skill level of all members and to communicate the capabilities through either formal or informal channels. The shared belief in the strategic competency of the organisation as a whole will result in teamwork towards the organisational goals.

This organisational culture of strategic competence must also be visible in the cultures of projects. The organisational culture should support the project team in the belief that all the accumulated competencies within the organisation are available to the project team.

c) Trust / Equity

In projects, it is difficult to build trust between people in the limited time spent working on a project. It is therefore important that a culture of trust is prevalent throughout the organisation. This will ensure that a project culture of trust is established much faster.

Organisations that foster a culture of trust between the organisation and employees will reap the long-term benefits. Workers must trust the organisation not to take more from them than they will receive from the organisation. Workers that trust the organisation in this sense will not feel exploited and will be more committed to the organisational goals.

Feelings of inequity will lead to disloyal behaviour and a resistance to achieve the organisational goals. When organisations show workers the mutual benefit in change, resistance to this change will be far less than when the perception exists that the change is only in the interest of the organisation and its management.

According to Kim and Mauborgne (1997), workers are usually more interested in the fairness of the process that is followed to reach or implement a decision, than the actual outcome of the decision. The three principles of a fair process are engagement, explanation and expectation clarity.

1. Engagement means involving employees in the decision making process. Employees should also be given the opportunity to give input and refute the merits of ideas and assumptions made by others. It is important in promoting trust in the organisation that these comments be given without the fear of repercussions and are seen as constructive criticism.

2. Explanation of the decision, the alternatives considered and the process used to reach the decision, is the second principle of fair process. It is important to communicate this to the employees involved and affected by decisions. Employees will more readily accept decisions they perceive to be impartially made and in the best interest of the organisation as a whole.

3. Expectation clarity clearly defines the rules that will be used to judge the performance of employees. Employees must clearly understand the measures

that will be used and the penalties for failure. This will ensure that everyone understands the impact of the actions that is taken.

Another important manifestation of trust in organisations is the tolerance for mistakes. In organisations where managers encourage employees to admit mistakes, all employees can learn from these mistakes. This will ensure mistakes are not repeated. This requires maturity from management and a commitment to learning.

Trust is also a major part of the culture required for successful knowledge sharing. The success of knowledge sharing depends on people being able to admit their ignorance and lack of knowledge on a certain topic. In a culture of trust where this ignorance will not be used against the knowledge seeker, and will not be construed as incompetence, knowledge sharing will succeed.

This demands maturity from all parties, and a common understanding or value that encourages people to admit their lack of knowledge in the search of new ideas. Top management can set an example in this regard by asking the opinions of workers at all levels that have experience and knowledge in certain fields. It is however important that management must act on the new knowledge and not ignore it.

This culture of knowledge sharing will develop in the organisation when highly influential and otherwise knowledgeable people are visibly searching for knowledge and are encouraging the sharing of knowledge.

d) Adaptability

Organisational cultures need to change with changes in the environment. Cultures that resist change will slow down innovation, and lose competitive advantage by not moving fast enough to keep up with the changing market. This is emphasised by the following quote from Jack Welch, CEO of General Electric. "*When the rate of change outside exceeds the rate of change inside, the end is in sight*" (Havenga 2001, p. 3). When organisational culture is used as a vehicle for organisational change, it is important that the culture must change as well, with new requirements from the environment. This change needs to happen or the organisation will be limited by its culture.

The organisational culture proposed in this chapter supports knowledge sharing and the functioning of the knowledge market in the organisation. The knowledge market

functions by people supplying knowledge and receiving increased credibility and respect from the receivers of knowledge. In an organisation with a well-functioning knowledge market, the reputation of being an expert in a specific field is the source of employees' power. This reputation can only be enhanced through the sharing of knowledge. An organisational culture that supports the knowledge market will prevent knowledge hoarding and reward knowledge sharing.

As a senior manager at American Management Systems (AMS) puts it, "*It's not what you know that gives you power; it's what you share about what you know that gives you power*" (McDermott and O'Dell, 2000). This is the most important point from a knowledge-sharing viewpoint.

If the existing culture in an organisation does not reflect the culture discussed in this chapter, it is necessary to transform the organisational culture. In the next section methods to change the organisational culture is discussed.

5.1.3 INFLUENCING ORGANISATIONAL CULTURE

Organisational cultures develop through the interaction of people. In order to change the organisational culture, it must be influenced by people in the organisation. In this chapter ways to influence the organisational culture is discussed.

The people that are often most influential in affecting change in an organisation, have informal roles in the organisational culture. These people must be identified and their specific roles used when change in the organisational culture is needed. Deal and Kennedy (1982, p. 90) describe the following roles.

a) Whisperers

The whisperers are people that have access to and influence with the boss. These people often do not occupy important posts within the organisation, and are mostly anonymous except to the leaders that listen to them.

One of the skills needed by whisperers, is the ability to read the boss' mind quickly, accurately and with few clues. Secondly these people will have a vast support network of contacts within the organisation. The whisperer uses this network to help the boss stay current with all that happens in the organisation.

Whisperers are powerful figures in the informal organisation, and usually have a good feeling for the state of culture in the organisation. Whisperers could sometimes be used to bring change initiatives to the attention of the organisational leaders.

In large projects, these people should be used to gain information on what is going on in all the different parts of the project. By using their influence with important role players, changes in the direction or culture of the project can be initiated.

b) Gossips

Gossips are the people that transmit the day-to-day happenings in the organisation. The news distributed is intended for entertainment value and will often not be true. Gossips can however be useful when organisational legends are formed. Legends are part of the culture and are told as ways of explaining how the organisation reacts to challenges. These legends are distributed throughout the organisation mostly by gossip. News of failures will travel faster in organisations than news of success. This in a good way to quickly distribute lessons that was learned from mistakes to all members of the organisation.

In project organisations, gossips will spread the triumphs and failures in specific projects to all the members of the organisation. This is a useful organisation-wide communication tool and must be used to spread stories of how people were rewarded for sharing knowledge. This will ensure mistakes and failures are not hidden, but communicated to all concerned.

c) Secretarial sources

The clerical workers of an organisation are the people that know the state of tension among the lower level workers as well as the top level. Secretaries are often well informed of the behaviour, likes and dislikes of the managers they serve, as well as the lower level staff that works through them with the managers.

When evaluating the culture of an organisation on different organisational levels, secretaries will be a very useful source of information.

d) Spies

Spies are of great importance to many senior managers in organisations. They are usually very loyal and have access to many different people. Spies will know what is

happening in other functions and projects in the organisation and will have information that is not usually accessible to managers. Spies can be useful to establish the source of resistance to changes.

In order to address the resistance, it is important to find out who are the trusted leaders of the resistance. Spies can help to find these persons, and then the other informal role players must be used to change their attitude.

The informal roles in the organisation are very important in changing the organisational culture. Managers that see the need to change the organisational culture must use these people to their advantage.

Another way to influence the organisational culture is through the use of leaders and influential peers. These people are respected in the organisation and can be used to motivate others to accept the changes through subtle reprimands if knowledge is withheld and recognition when knowledge is shared. This will show that knowledge sharing gives one power, not knowledge hoarding. The praise and attention of these people will be a strong enough bargaining chip to kick-start the knowledge market in most organisations.

James Sarros (2001) found that leaders have a greater influence on culture than they are influenced by the organisational culture. It is therefore important to have the correct people leading the organisation. Leaders that do not embrace and demonstrate the principles of knowledge sharing will not be able to create an organisational culture that do.

Organisational culture is not only important for a sustainable knowledge management initiative, it is also important for the implementation of such an initiative. In the next chapter the role of organisational culture in the implementation of a knowledge management initiative is discussed.

5.1.4 THE ROLE OF ORGANISATIONAL CULTURE IN THE IMPLEMENTATION OF A KNOWLEDGE MANAGEMENT INITIATIVE

The implementation of a change initiative such as knowledge management can be simplified with the use of the existing organisational culture. Organisation members will more readily accept an initiative that is supportive of the culture, as it does not

expect them to change their values. The culture can be used to drive change in the organisation, and in the way work is performed.

Small changes can be made to the organisational culture, if employees accept the initiative. The initiative must therefore embrace the positive aspects of the organisational culture, in order to affect change to the negative aspects.

By connecting the initiative to well accepted values in the organisation, it will be accepted by all organisation members that subscribe to these values. Employees form the invisible values in the organisation through years of interaction. These are the accepted unwritten rules and must be obeyed and supported in the implementation of the initiative to ensure success.

By using the accepted values, employees will subscribe to and even defend the knowledge management initiative because it stems from their own convictions. This can later lead to a change in the organisational culture, once everyone has accepted the validity of the initiative.

The well-established social and technical networks in the organisation must be incorporated in the knowledge management initiative. Because the employees themselves form these networks, a knowledge management system that uses these networks will be partly designed by the employees. This will ensure a greater use of the system than any enforced structure. In section 5.3.3 on the technologies used to distribute knowledge, this will be discussed in more detail.

The organisational culture is developed through the interaction of individuals in an organisation. In the next section, the role of individuals and teams in project organisations is discussed.

5.2 PEOPLE

Knowledge unlike information can only be generated by and stored inside people. It is possible for people to influence their environment in such a way that knowledge is also captured in corporate structures, it is however the people that interact within these structures that bring out the potential of the captured knowledge.

In the previous section on organisational culture the focus is on a large group of people that collectively form the organisation. This section will focus on the

individuals and smaller groups or project teams within the organisation. The formal roles and interaction of people will be described in the organisational diagram of a project organisation. The roles of employees responsible for the knowledge management functions will be described as well.

Knowledge workers fill these roles in the organisation. A discussion of the attributes and skills of the individual knowledge workers will follow a description of knowledge workers. The last part of this section will focus on the effectiveness of project teams and on how to increase team effectiveness.

5.2.1 ORGANISATIONAL STRUCTURE FOR KNOWLEDGE MANAGEMENT AND PROJECT MANAGEMENT

In a project management organisation, certain roles must be defined in a formal structure of the organisation. These project management roles can be found in most project management organisations and include the project manager, portfolio manager, technical personnel, support personnel and functional managers. The other roles of importance for this study are the roles of people responsible for knowledge management in the organisation and include the chief knowledge officer, knowledge managers and content experts as presented in Figure 10.

In this section the proposed organisation structure for a project management organisation is discussed first. This organisational structure includes the roles responsible for knowledge management according to the knowledge management model proposed in this study. The details of the roles in the organisation are discussed in the second part of this chapter.

The typical matrix organisation structure that is popular in many project management organisations can be seen in Figure 10. This organisational structure has a chief executive officer (CEO) or managing director (MD) as its head. The organisation is then divided into departments, reporting to an executive manager. The executive managers report to the CEO or MD and are known as the top management of the organisation. Each department consists of different functions controlled by a functional manager. So far this is a typical functional structure with line reporting and top-down management control. A matrix organisation is a functional organisation with cross-functional teams reporting to a project manager.

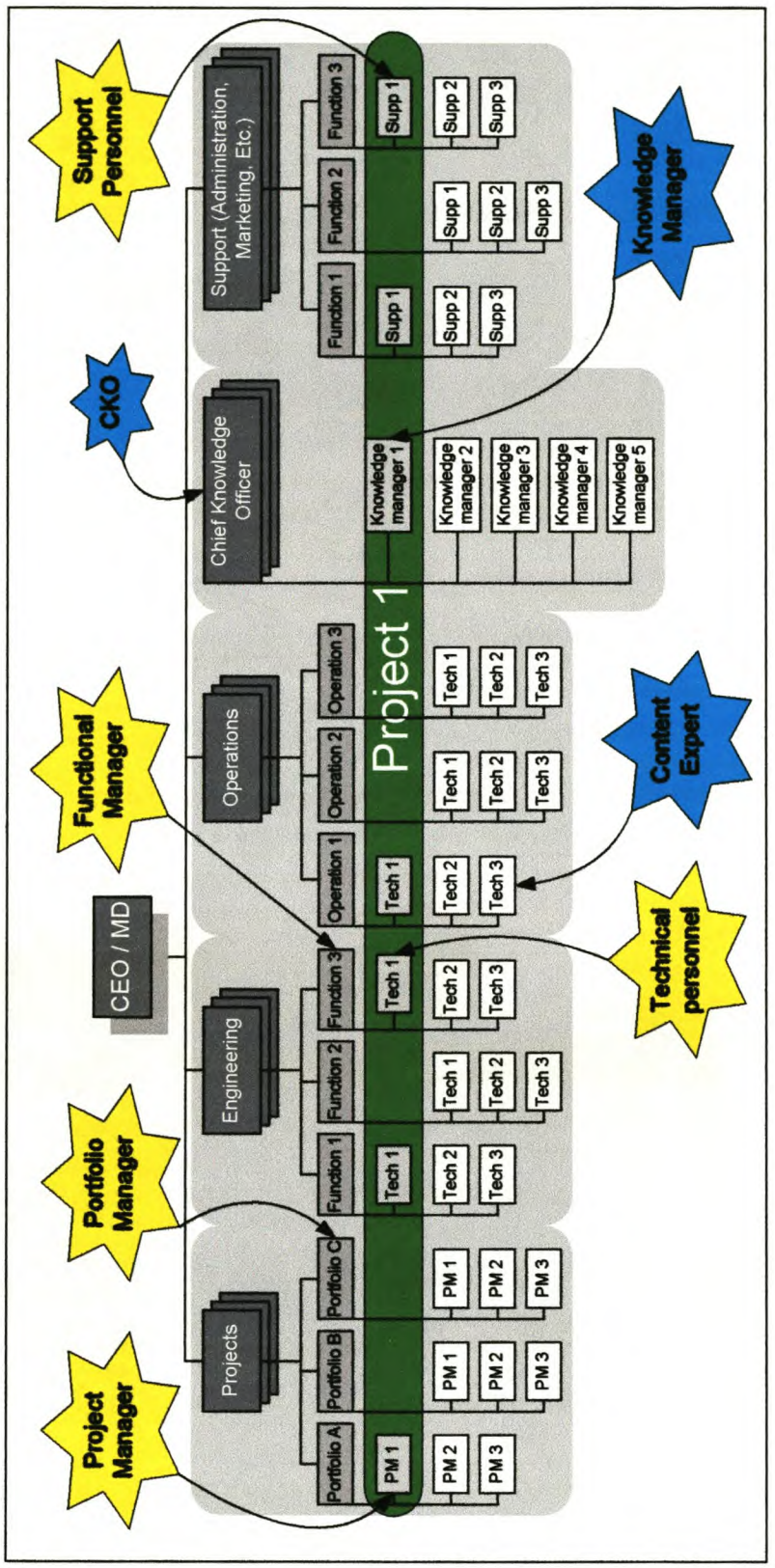

Figure 10 The organisation structure for knowledge management in project management organisations

In a matrix organisation project teams are made up of team members from different functions. Project managers belong to the project function and report to a portfolio manager that has line responsibility over these managers. The technical and support personnel belong to specific functions and report to the project manager for project related activities and to a functional manager for functional activities.

This dual reporting is seen as a negative aspect of the matrix organisation structure and can result in conflicts of interest between the functions and the project. One way to resolve these conflicts of interest is to have project portfolio managers with the same organisational authority as functional managers. The **PMBOK Guide** (PMI 1996, p.22) refers to this structure as a strong matrix organisation. The functional manager and the portfolio manager can then resolve a conflict between a functional group and a project. If no consensus can be reached on priorities for resource scheduling, the appropriate executive members can intervene to ensure co-operation between the technical function and the project function.

In organisations that encounter problems with conflicts between functional groups and projects, the organisational structure is usually organised to give more power to the functional groups. In this scenario, the project manager usually has to compete for resources with a functional manager that has more authority in the organisation.

Another reason for the failure of matrix organisations is the lack of formalised project selection and prioritisation. Organisations that select and approve projects according to resource availability and give each project a priority have little trouble in settling resource disputes. Project priorities should be assigned at the portfolio and functional manager level. This will ensure that all managers have an opportunity to give input into the process. Employees can also schedule work according to the priorities agreed upon.

Any organisation that implements knowledge management will have roles responsible for performing knowledge management functions. These roles must be integrated with the other functions in the organisation.

A project management organisation that wants to implement a knowledge management initiative can integrate this function as shown in Figure 10. The chief knowledge officer (CKO) is the executive level representative of the knowledge

management function. This role can be combined with the role of chief information officer (CIO). A potential danger in combining these two roles is that the knowledge management initiative could then be focused too much on the technology enabler. This will be to the detriment of the people and organisational culture enablers.

The chief knowledge officer has line responsibility for the knowledge managers. These knowledge managers must ensure the knowledge management process is used to the advantage of projects. The content experts are part of the technical or support personnel and are gatekeepers of the organisational knowledge. These persons are responsible to ensure new knowledge, which is distributed and stored in the organisation, is appropriate and of future use to the organisation.

The roles and responsibilities of project management personnel as well as knowledge management personnel are discussed below. The knowledge management responsibilities of project management personnel are also discussed.

a) Portfolio and functional managers

Functional managers have line responsibility for the personnel in their functions. The portfolio manager is the functional manager for the project function. The responsibilities of this role are focussed on the supply, management and development of resources. The assumption is made that all work is done in a project structure and that functions are only responsible for supplying projects with resources.

The allocation of resources to projects should be done through collaboration between the functional managers and portfolio managers. This structure assumes the project manager is on the same organisational level as technical and support personnel. It is therefore not the role of the project manager to discuss resource allocations with functional managers.

Conflict can be avoided by using a process of prioritisation of projects and joint resource decision-making between portfolio managers and functional managers. The decisions on resource allocation include human resources, funds, machinery and facilities.

b) Project manager

According to Kerzner (1998, p. 10), "*the project manager is responsible for co-ordinating and integrating activities across multiple functional lines. In order to do this the project manager needs strong communication and inter-personal skills, must become familiar with the operations of each line organisation, and should have a general knowledge of the technology needed in the project*".

The model of team effectiveness that is discussed in section 5.2.4 stresses that leadership is a group responsibility and should not be delegated to the project manager. The project manager is however responsible for the management of the project and have overall responsibility for the success of the project. Project managers must ensure the empowerment of team members is achieved without jeopardising the project. This requires project managers to move along the continuum of management as described by Tannenbaum and Schmidt (1973). The continuum consists of the seven management behaviours as depicted in Figure 11.

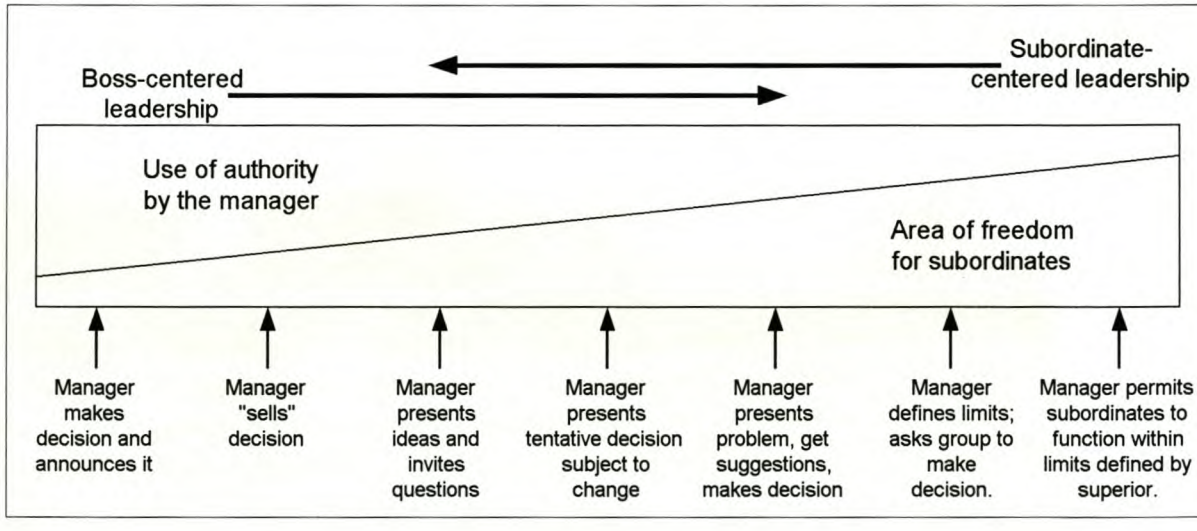

Figure 11 Continuum of management behaviour

During the movement along the continuum it is important to be clear and honest with subordinates as to the authority that the project manager will keep, and the role and responsibilities of subordinates. In Figure 11 it can be seen that a manager on the left hand of the continuum operates in the command and control mode that is typical of military organisations. The manager that operates on the right end of the continuum totally empowers team members as far as responsibility is concerned. Empowerment is important for encouraging creativity and knowledge creation. Team

members that are empowered to take responsibility will seek out and share knowledge to achieve project success. Project managers that retain all authority will limit team members in their use of knowledge.

Some of the most significant characteristics of an effective project manager as found by Thomas H. Zimmerer and Mahmoud M. Yasin (1998, p. 33) in a survey among American project managers are as follows:

- Leadership by example
- Visionary
- Technically competent
- Decisive
- A good communicator
- A good motivator
- Stands up to upper management when necessary
- Supportive team members
- Encourages new ideas

Leadership by example is of great importance for project organisations that implement knowledge management initiatives. Leaders and managers that show a willingness to share and use all available knowledge will encourage others to do the same. A project manager can be more decisive with the correct use of information and knowledge.

Project managers can encourage an organisational culture of trust with team members that work towards a common goal. This is very much dependent on effective communication between the project manager and the project team. It is the responsibility of the project manager to ensure proper channels of communication exist and are used. Team members that understand the goals of the project and the organisation and that can trust the project manager will be more supportive of the project manager.

The encouragement of new ideas is one of the most important characteristics of a knowledge intensive organisation. The project manager is exposed to the risk of failure, because of new ideas. This risk can be minimised by the effective use of knowledge. All innovation is however exposed to risk because of uncertainty. It is important that organisations acknowledge this risk and consider it when the

occasional failure does occur. This is very important in promoting an organisational culture of trust as discussed in the previous section.

One of the most important skills of a successful project manager is conflict resolution and the use of constructive conflict to encourage innovation. Destructive conflicts in projects often arise from factors such as improper planning, ineffective communications, vague objectives and expectations, a climate of distrust and disrespect within a team, undue external pressure, personality conflicts and resentment.

From a knowledge management viewpoint conflict management and resolution is the most important role of the project manager. Project managers must prevent destructive conflict if possible, but when conflicts do occur, the following five methods can be used to resolve or manage it.

Compromise can be used when two or more team members have constructive ideas to contribute, but cannot reach enough of a common ground to work together effectively. The project manager must then act as mediator to help both sides to make compromises to ensure co-operation.

De-emphasis is used to help parties focus on commonalities, instead of trying to narrow the dissimilarities, as is the case with compromise.

Retreat involves the avoidance of a problem. This stalling tactic will sometimes lead to the conflict resolving itself with time. This technique can be used to prevent minor incidents or misunderstandings from becoming major conflicts. This is however not the correct approach to solve really important and complex conflicts.

Enforcement can be used when the team has clearly defined rules. The project manager can enforce rules when it becomes evident that a team member will not collaborate and act in the team interest.

The direct approach is the preferred method for resolution of problems. Here the project manager discusses the underlying issues involved in a conflict with both sides and recommends remedies. If the process used to arrive at remedies is fair, all the parties involved will more easily accept it.

It is the opinion of this author that project managers should empower people to lead and control themselves. This can be done by a strong goal oriented focus. The project manager is therefore a facilitator that must promote team-effectiveness. This facilitation should not be focussed at controlling the team but at increasing team effectiveness, as effective teams are more successful than tightly controlled and managed teams.

c) Project technical and support personnel

The technical personnel in a project are the employees that will ensure that the project progresses through the life cycle phases of the product or service. These team members will add the substance to the initial project concept to transform it into a deliverable product or service that conform to the scope of the project. The technical personnel contribute value directly to the end result. The typical job descriptions are analysts, engineers, scientists, consultants, etc.

The support personnel give support to the technical personnel and the project manager. These team members are more involved with the management and control of the project, than the product or service that is generated. The typical functions involved are cost control, scheduling, finance, change control, etc.

These employees are all knowledge workers. The knowledge management skills and attributes of knowledge workers will be discussed in the next chapter.

d) Chief knowledge officer (CKO)

The appointment of a chief knowledge officer is recommended as one of the first steps in starting a knowledge management initiative. Knowledge management is a multi-disciplined undertaking that will need a strong champion to help break down barriers and implement cultural changes. The leaders in the organisation influence the organisational culture, as discussed in the previous section. The chief knowledge officer must influence the leaders at the top to ensure this happens.

Three of the responsibilities of the CKO that are of particular importance are (Davenport and Prusak 1998, p. 115):

1. Building an organisational culture of knowledge sharing.
2. Creating a knowledge management infrastructure.

3. Ensuring that the knowledge management initiative is economically justifiable.

This is also a good fit to the enablers proposed in this document. The first responsibility mentioned by Davenport and Prusak corresponds to the enabler of organisational culture. The second responsibility corresponds to the enabler of technology. It can be seen that these authors still feel that people are the responsibility of the human resource department or of line managers, and not of the CKO. This author concurs with this argument and feels that the CKO is responsible for technology implementation, the fostering of a culture of knowledge sharing and the integration of the knowledge management process with project management work processes.

The description or make-up of the CKO applicant is not yet fixed, and Thierauf (1999, p. 320) argues that the person fits into one of three moulds.

Firstly, the CKO can be a strategist who uses knowledge for strategic advantage. Secondly, the CKO can be an information technologist that is interested in how information and the subsequent knowledge generated from information is collected and dispersed. Thirdly, the CKO can be a human resources expert who capitalises on collective experience as a corporate asset.

Although the CKO can be appointed from any one of these groups, the ideal candidate will have experience in each of these fields. Appointment of an information technologist bears the danger of the knowledge management initiative focussing on technology only, whereas the other two enablers, organisational culture and people, are equally, if not of greater importance. Rather than appointing the CKO from a specific department, it is recommended that a person with the necessary characteristics (see Table 3 on the next page) be selected.

Table 3 Characteristics of a chief knowledge officer

Characteristic	Explanation
KNOWLEDGE MANAGEMENT EXPERIENCE	A deep experience of aspects of knowledge management, including the creation, dissemination or application of knowledge.
INFRA-STRUCTURE KNOWLEDGE	The person should have an excellent grasp of the technical infrastructure; this includes the information and operational infrastructures, and must be able to integrate knowledge management into the business processes of the organisation.
KNOWLEDGE ON ORGANISATIONAL CORE COMPETENCIES	Must know what the core competencies of the organisation are, and how knowledge and information will support the organisation in using these competencies to gain a competitive advantage.
TOP MANAGEMENT SUPPORT	The CKO must have the respect and support of the CEO and the board members of the organisation to ensure that top management supports change. Organisational leaders will set an example that will help change the organisational culture.
INDEPENDENT, NO BENCHMARKS OR BUDGET	Must be able to work independently, sometimes without benchmarks or budget. This new initiative must be implemented at all levels of the organisation, while usually only reporting to the CEO.
KNOWLEDGE ON COST OF TECHNOLOGY	Must know how to use technology economically. Knowledge management must be economically viable, and the technologies needed must be part of the business case.
CHANGE IN KNOWLEDGE REQUIREMENTS	Must be able to manage old and present knowledge as well as putting actions in motion to acquire new knowledge. Knowledge is dependent on the organisational and competitive environment and will change with changes in the environment.
BUSINESS & TECHNOLOGY CONTACTS	Must operate comfortably in the business and technological areas of the organisation. The CKO must have a network of contacts within the organisation that can be used to initiate change.

The most important characteristics of the CKO are inspirational leadership and change management skills. The CKO, supported by the other leaders in the organisation, will be responsible to facilitate the change in the organisational culture.

Because successful knowledge management is largely dependent on people and their interactions in the organisation, this person must be able to inspire a need for change in all employees.

e) Knowledge manager

The knowledge manager in an organisation is the person responsible for the day-to-day maintenance and operation of the knowledge management process. The chief knowledge officer is the organisational head of the knowledge managers as can be seen in Figure 10.

The knowledge managers are responsible for motivating workers to transform a part of their knowledge from the tacit to the explicit. The knowledge managers are involved with the distribution of relevant knowledge to the members of the organisation that need it. They must also ensure that knowledge is codified and stored in such a way that it can be found, retrieved and used successfully.

The knowledge managers must motivate workers to use knowledge in new and productive ways as well as to capture knowledge in work processes.

The knowledge managers must have a varied background according to the work that will be done. Librarians and information technologists will have some of the skills needed for capturing and distributing knowledge. Human resource practitioners will have a good feel for the cultural and political issues involved when working with people. It is however important that all knowledge managers have a clear understanding of the total potential of knowledge management.

The cultural issues involved with knowledge management forces all knowledge managers to have good communication skills. Motivation and trust can only be achieved through clear communications.

In the project organisation, a knowledge manager must be intimately involved with the project team. The trust and co-operation of all members will only be achieved if the knowledge manager is of value to the other members. This means that the knowledge manager must actively seek to develop the knowledge potential of the team. This can be done by facilitation during problem solving and decision making meetings.

The knowledge manager must not be seen as an outside functionary who will be called in at the end of the project to finalise the documentation and notarise the lessons learned. By being involved in the total project life cycle the knowledge manager can help capture knowledge at all stages that can be useful to the rest of the organisation.

By motivating workers early on in the project life cycle to use and transform knowledge, innovation can be triggered and directed. Knowledge managers are also responsible for capturing the networks of expert contacts that each project member

has established. These networks will help with the distribution of knowledge as well as being a guide for knowledge searches.

The knowledge managers are also responsible for the identification and utilisation of content experts from the functional groups. The knowledge managers will guide knowledge to the relevant expert, and motivate the experts to update their own knowledge base.

By using content experts, the technical burden is taken off the shoulders of the knowledge managers. The knowledge managers now become facilitators and integrators of the knowledge that is inside the experts and their networks.

f) Content Expert

Content experts are the gatekeepers of the explicit knowledge bases of the organisation. Explicit knowledge can be the recorded and documented information, workflow or methods used in the operations of the organisation.

The content experts will be from among the technical and support functions in the organisation. In the networks of expert contacts of the technical and support personnel, the content experts will be people contacted for technical advice.

The content experts are used to review any additions to the knowledge base to see if it is original and where improvements are proposed, the content expert will evaluate the new knowledge against the accepted knowledge.

Content experts can also be used to review proposed training programs to evaluate the technical content. It must also be stressed that the identified content experts are the most valuable workers for the speciality in which they are experts. These experts must be used to train others in their field and through succession it must be ensured that knowledge is not lost when the expert exits the organisation.

5.2.2 KNOWLEDGE WORKERS

It is important to define the term knowledge worker before the discussion commences. All workers can contribute knowledge to an organisation, but knowledge workers contribute largely through their knowledge.

The definition for knowledge workers used by Borghoff and Pareschi (1998, p. 57) describes them as workers that are "*changed by information in their environment, and they in turn seek to change others through information. The information is not structured as with procedural work, but diversity and ad hoc behaviour patterns are common.*"

Karl-Erik Sveiby (1996) has four categories of personnel in the knowledge organisation. These are professionals, managers, clerical staff and the leader. The definitions for professionals, clerical staff and managers can be compared to the roles of technical personnel, support personnel and the project manager respectively as used in the previous chapter of this document.

According to Sveiby's definition, only the professionals are knowledge workers. In this thesis, knowledge work is defined as solving complex problems by using knowledge. All employees that do knowledge work are defined as knowledge workers.

When project support personnel or project managers are confronted with complex problems, they also use knowledge to solve these problems. Knowledge workers, as defined by Sveiby, will however be involved with knowledge work for the greatest part of their work, whereas managers will be involved with managing people for the most part. Although the discussion of knowledge workers is applicable to all employees that perform knowledge work, the practical application will be to those people that perform mostly knowledge work.

The knowledge workers with the most knowledge to contribute to a company are essentially volunteers, according to Dave Ullrich (1998). These workers are likely to find employment with a number of organisations. This means that although knowledge workers do not work for free, they have a choice as to where they work. There must therefore be reasons for the worker to form an emotional bond with the organisation. The motivation and loyalty of these workers are based on challenges to the individual in the organisation as well as an understanding of their contribution to the team. Knowledge workers that find their work has become routine and without challenge will move on to more challenging employment.

This is a challenge for human resource mangers in organisations that want to recruit, develop and retain knowledge workers. Reward systems currently employed by

organisations will have to be adjusted, to ensure knowledge workers are not only rewarded for the time spent at work and their contributions towards reaching organisational goals. They will also have to be rewarded for the sharing and use of knowledge, and most importantly, for transferring knowledge from human capital to structural or organisational capital. In this way knowledge would not be lost when the knowledge worker leaves the organisation.

The competence of the group of knowledge workers can be increased by using the six tools mentioned by Ullrich (1998) and the best practices named by Quinn, Anderson and Finkelstein (1996).

1. Buy new workers by selection from outside the organisation. In the selection of new workers it is important to identify the knowledge that is needed in the organisation in order to identify the holder of that knowledge. The risk involved with bringing in new knowledge workers is that the existing employees might be alienated. Workers brought in from outside the organisation might be more reluctant to become part of the organisational culture, and in so doing resist changes that are rooted in the existing culture.
2. Build the competency of the current work force by formal training and informal learning. Managers must however be willing to accept changes to the existing ways work is performed, as new knowledge is brought to bear and employees are empowered by new knowledge.
3. Constantly increase the challenges faced by knowledge workers. By demanding almost impossible stretch targets from subordinates, managers can push workers beyond the complacency of their established knowledge bases. This will have to be coupled to a tolerance for mistakes. When employees use new knowledge to gain an advantage in an established field, mistakes will be made.
4. Borrow knowledge from outside the organisation by hiring consultants. It is important to transfer the knowledge from the consultant to the workers within the organisation. This will enable the organisation to function without the constant help from consultants and motivate workers to tackle challenges previously left to consultants.
5. Bounce the individuals that fail to perform to standards. Organisations must be willing to do selective pruning of the workforce in order to ensure that the competencies of all workers are of a high standard. This must be done with regard to individual needs. Employees that are forced to move on must be helped

as far as possible to find employment that is more in line with their individual needs and knowledge competencies.

6. Bind employees to the organisation by finding out what will keep critical employees in the organisation.

These six tools will ensure that the competency of the workforce is continually increased.

5.2.3 ATTRIBUTES AND SKILLS OF INDIVIDUAL KNOWLEDGE WORKERS

In the previous section it was argued that knowledge workers are mostly involved with knowledge work. The attributes of these workers and the skills needed to perform the work will be discussed in this section.

The company TFPL (Oxbrow, 2000) describes the skills and competencies needed by individuals in knowledge organisations. The breakdown of these skills and competencies into four sections: information literacy, knowledge management enabling skills, environmental skills and core competencies is shown in Figure 12.

The information literacy concentrates on the use of information in business processes, for problem solving, for strategic planning and in innovation. Knowledge management enabling skills are the specific skills needed for successful use of information and the management thereof. Environmental skills are needed to interact with the environment, and specifically other people. The core competencies of the individual are the basic skills and personal attributes on which the other competencies are built.

In the project organisation, information literacy skills are important to know what information is needed at specific phases of the project. The correct information for decision-making must be identified, and projects must be controlled with the use of information generated by the project team.

Fast cycle decision-making is just one of the information literacy skills that are important for knowledge workers in project organisations. The principle is to make a decision quickly and be right seven times out of ten. As Walter Reitman puts it, "*If you make the decision quickly, and it turns out in a week or two or three to have difficulties nobody anticipated, you stand a pretty good chance of being able to*

reverse it or modify it and still be in time to deal with the market problems" (Prewitt, 1998).

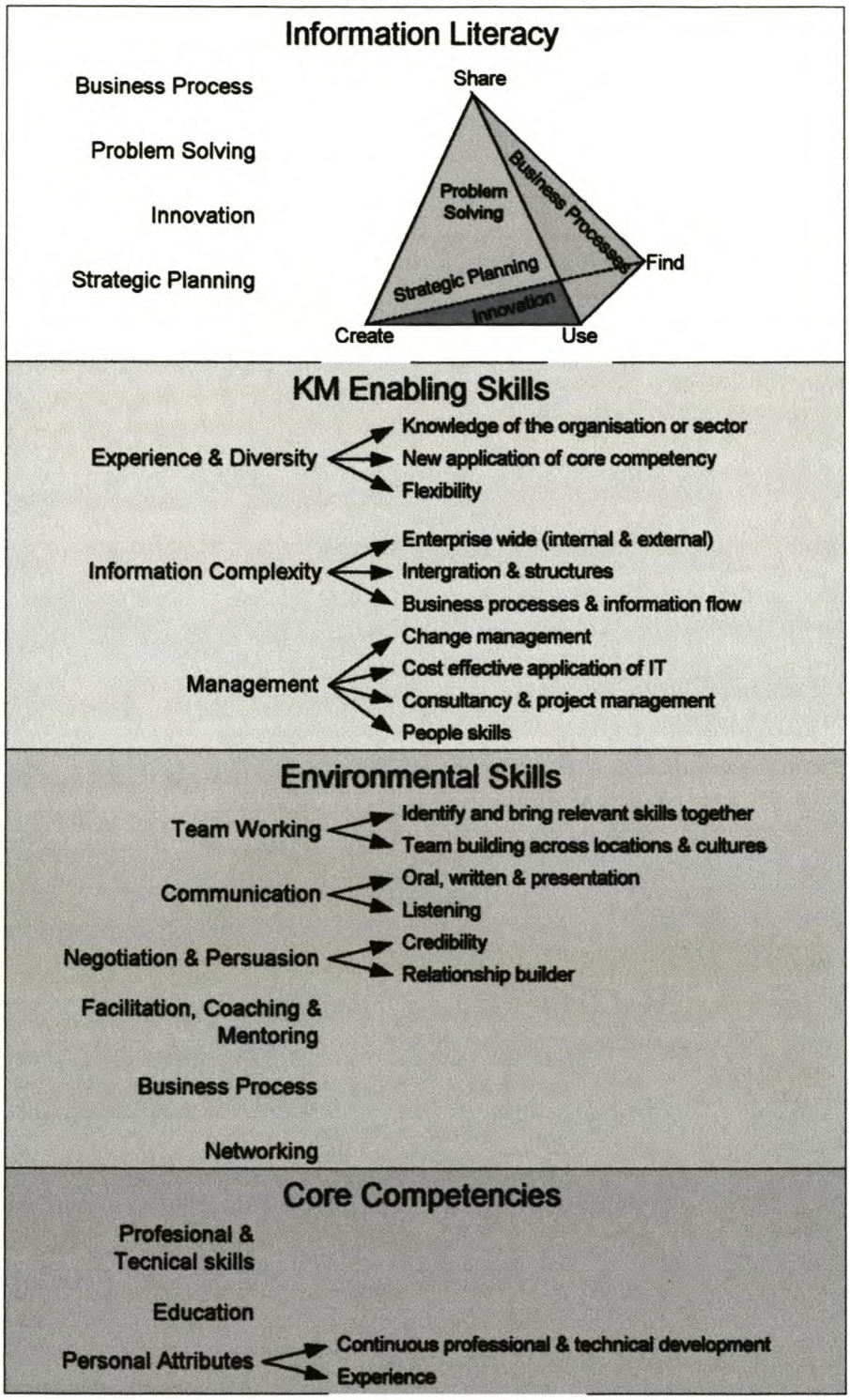

Figure 12 Skills and competencies of knowledge professionals

Time consuming searches for information will not always ensure that decisions are correct. It is often of more value to have this time available later, when market and

scope changes will force a rethink of the decision. The information on which the original decision was based will often be invalid at this stage. Shorter product life-cycles, compressed product development life-cycles, and rapidly opening and closing market opportunities all underscore the importance of fast cycle decision making.

The knowledge management enabling skills will ensure people in project organisations can find and recognise the appropriate knowledge and information, as it is required. People must know how to integrate knowledge in the work processes of the organisation.

Environmental skills are needed by project organisation members in order to work effectively with others. Projects are organised in teams and interaction between people is therefore essential. Organisation members must be able to communicate and influence others in order to share and use knowledge in projects.

These attributes should be considered when recruiting and evaluating individual knowledge workers. The skills should be developed to ensure greater knowledge management performance by knowledge workers. This section only focused on the attributes of individuals in the organisation. In project organisations the proper functioning of teams are of as much importance. The following section will discuss the role of teams in these organisations.

5.2.4 TEAMS OF KNOWLEDGE WORKERS

The discussion of the role of teams in a knowledge organisation must begin with a definition of a team. The following quote will be used as a definition.

"*A team is a special designation given to a group of people who not only share a common goal, but are also aware of the very nature of their interdependent roles, and how their respective talents complement their efforts to assure project success. Effective teams encourage free discussion, open disagreement, expression of feelings, mutual influence and have clear leadership*" (Kezsbom, 1990).

This definition states that team members are interdependent on each other to perform certain tasks that will help the team to achieve a common goal. Teams, unlike groups, also have leaders and followers.

Project teams are therefore teams as defined by this definition, as they are formed to accomplish a specific goal (the project scope). Their members are interdependent on each other to perform tasks and they have a leader in the project manager.

The advantages in the use of teams in organisations include the more effective use of human resources, a faster response to market demands, and greater knowledge utilisation. The greater utilisation of knowledge stems from two sources. Firstly, teams bring together individuals with different knowledge bases and information that is applied to solve mutual problems. These problems are related to the goal of the team. In the project management environment these problems are related to the successful completion of the project.

Individuals do not only contribute different sets of information, but the diversity of the team will also lead to the investigation of a wider range of alternatives, and will therefore lead to more innovative solutions.

The enhancement of learning or the transfer of knowledge is the second advantage of using teams in knowledge organisations. Team members learn from others in the team, and take this knowledge to other teams they work in. This is therefore a very effective way of forming knowledge networks in the organisation. In traditional organisations with a functional structure, knowledge is very seldom transferred across functional borders. In an organisation that uses teams this cross-pollination of knowledge is ensured.

Just forming teams will however not necessarily lead to all the advantages mentioned above. Team effectiveness is dependent on several factors. Many models have been proposed for team effectiveness. The definition of team effectiveness by Guzzo will be used here to describe the attributes of an effective team. Effectiveness is defined by "*measurable group-produced outputs, consequences the group has for members and the enhancement of a team's capability to perform well in the future*" (Yancey, 1998).

From this definition it is seen that effectiveness is not just a measure of current performance and team outputs, but also of the team's ability to deliver performance in the future.

From the literature, several models for team effectiveness were studied. In Table 4 a comparison of these models is presented. The model proposed by Yancey is compiled from a study of the models proposed by Campion, Hackman and Guzzo. The team habits proposed by Charlton focus very much on a strong leader, he does however point out that the primary role of leadership is to give others the opportunity to be leaders as well. Yancey agrees with this and states that leadership should be "*a shared group responsibility, and not a delegated position*" (1998).

Table 4 Comparison of models of effectiveness

Elledge & Phillips (1994)	Charlton (2000)	Campion (Yancey, 1998)	Hackman (Yancey, 1998)	Guzzo (Yancey, 1998)	Yancey (1998)
Leadership	Focus	Context	Leadership	Task interdependence	Leadership
Roles	Communication	Job design	Structure	Outcome interdependence	Participation
Goals	Intrinsic motivation	Composition	Direction	Potency	Environment
Process	Trust	Process	Enabling situation		
Relationships	Self management	Interdependence	Organisational context		
	Empower & enable				

The model by Elledge and Phillips was adapted to include elements from the other models. This adapted model can be seen in Figure 13. The model consists of 6 dimensions of team effectiveness. Dimensions are leadership/management, job design, goals, composition, relationships and environment. Within each of these dimensions, certain elements must be considered to ensure specific outcomes from the dimensions. In Figure 13, the elements can be seen inside each box, with the specific outcomes on the sides of each box.

In the proposed model for team effectiveness, leadership and management are both included in one dimension. The role of leader must not be delegated to one person, i.e. the project manager. As mentioned earlier, both Charlton and Yancey conclude that different persons must fulfil the role of leader, as the need arises. It is therefore important to develop leadership abilities in all members of the organisation.

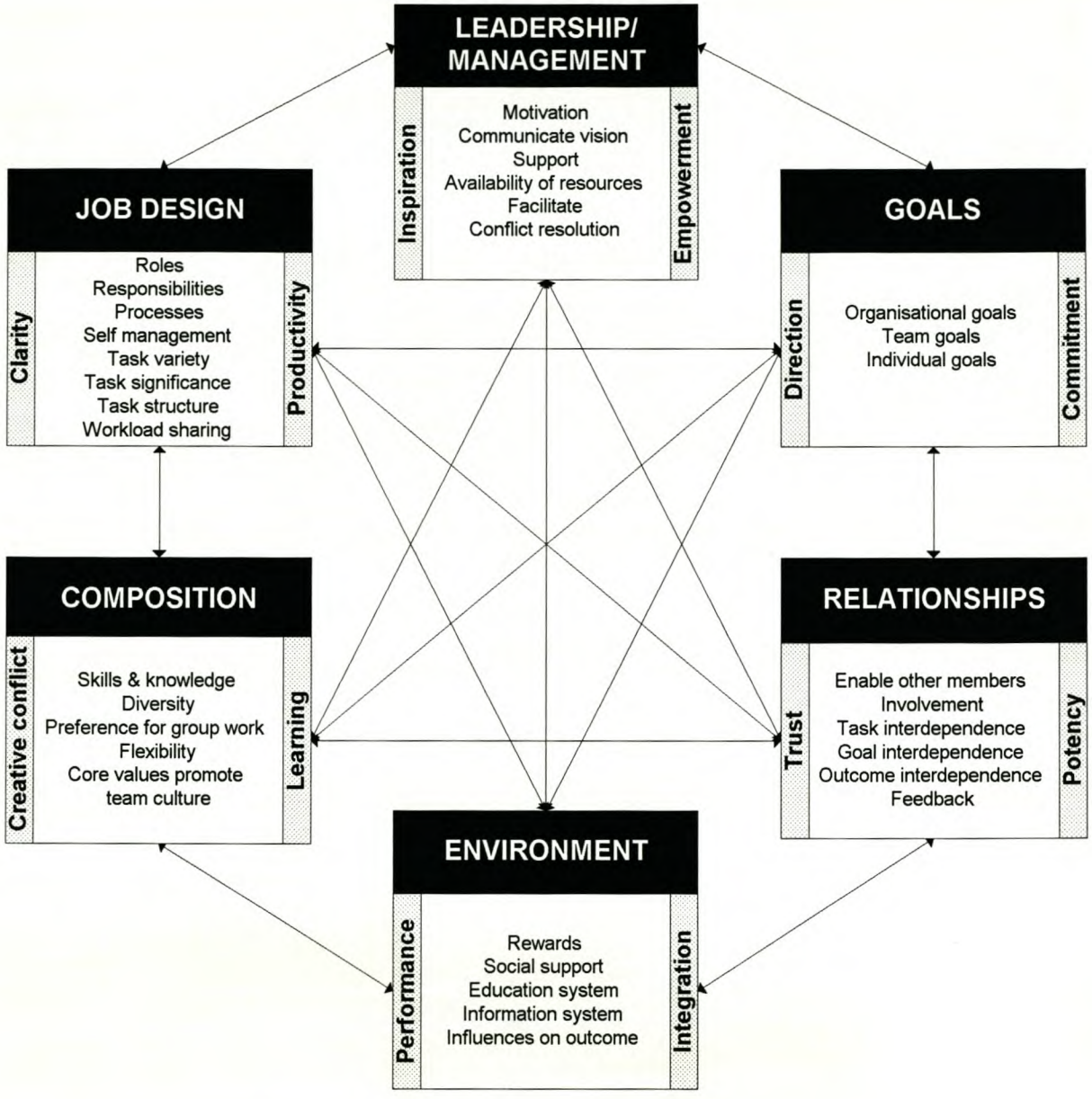

Figure 13 The model for team effectiveness

This model for team effectiveness summarises the dimensions and elements within each dimension that must be improved to achieve improved team effectiveness. Although this is a model for all teams in any type of organisation, it can be applied in project organisations with great success. The barriers to project team success identified by Nurick (1993) can be removed by the elements of this model. These barriers are the following.

a) Different points of view

The strength of a team is in the diversity of backgrounds, skills and talents of team members. This will however lead to members seeing the problem from their own points of view and a tendency to stereotype the viewpoint of other team members. This is especially true in highly technical projects where members communicate in different technical languages and codes.

In organisations with a history of conflict between functions, representatives from these functions may carry this into the team. The composition of the team based on interpersonal skills and the training of team members in these skills will help remove this barrier.

b) Role conflict

Team members will find themselves assigned to different roles in the project from the roles usually fulfilled in the functions of the organisation. The team will work towards project goals according to the different values from those established in the parent functions they represent. This, coupled with time pressures due to demands from the traditional roles in the parent functions, can lead to conflict.

The support from the organisation coupled with proper job design will ensure that this barrier is removed.

c) Implicit power struggle

Project teams usually comprise different levels of authority. Individuals with positions of power elsewhere in the organisation will try to recreate and exercise that influence in the team. This will result in members undermining the productive ideas of others in an attempt to gain personal power. This is usually to the detriment of team moral and performance.

Examples of implicit power struggles are often found in strategy development projects. Here top management and other employees are working together with equal status as members of the project team. Conflict and poor performance are often the result of managers not making the transition from leadership to team membership, and the unwillingness of lower level employees to contribute critically for fear of reprisals later.

Proper management of conflict resolution and a focus on the team goal can solve this problem. Interdependence of individual team members will also help to unite the team and to work towards achieving team goals and not only individual goals.

d) Groupthink

A project team that is working as a highly cohesive group, especially on special projects with high priority and status in the organisation will often develop a sense of detachment and elitism. This leads to reluctance in examining viewpoints from outside the team, as these viewpoints are seen as a threat to the existence of the group and its status of being elite.

Teams comprised of diverse team members will be less likely to fall into the trap of groupthink. Groupthink is increased when a team avoids conflict and can lead to narrow-minded decision-making. A team culture that uses constructive conflict to explore new avenues of knowledge will counter this barrier.

It is clear that the model for team effectiveness proposed in Figure 13 could be used to counter the barriers to project success.

The people enabler in the knowledge management initiative of a project organisation is built around the individual knowledge workers, and their interaction in effective teams. An organisational culture to support this interaction and encourage knowledge sharing is also essential for successful knowledge management.

The third knowledge management enabler that is needed in an organisation is technology that supports knowledge management. The next section will discuss the role of technology as a knowledge management enabler.

5.3 KNOWLEDGE MANAGEMENT TECHNOLOGY

The technologies used in promoting knowledge management are often called knowledge management systems. A knowledge management system can be defined as a system for managing the gathering, organisation, refining, analysing, and dissemination of knowledge in all of its forms within the organisation. It supports organisational functions while addressing the needs of the individual within a purposeful context.

This statement can however be misleading because knowledge resides mostly within people. This means that technology in knowledge management is used mostly to connect people with the right information, and with other people that have knowledge. Once people are connected and are able to work together, they use information in different ways according to the knowledge of the user.

The two most important factors in business are being first and being right. The technologies used in knowledge management help employees to achieve both by automating the knowledge management process.

The different technologies that can be used in the steps of the knowledge management process will be discussed separately. It must however be noted that integration of technologies is more important than the effectiveness of the individual software package. Knowledge management is all about sharing knowledge and connecting knowledgeable people. Without proper integration, frustration will stop even the most well developed initiative.

The knowledge management process will be discussed in detail in section 6 of this document. The technologies discussed in this section are used to automate the steps of the knowledge management process. The discussion of the technologies will therefore be according to the process steps.

5.3.1 TECHNOLOGIES USED IN KNOWLEDGE CREATION

The precise mechanism for innovation or knowledge creation is not yet known. One important observation is that a fortuitous chance observation is more likely to be utilised if more information is assimilated. Knowledge creation or innovation is an internal process in humans. Information is one trigger for this process. If people are exposed to new information, it can trigger the innovative process and new ideas can be generated. The process that will lead to this observation or idea generation is not known, but it is possible to expose knowledge workers to large amounts of relevant information and create an environment where people can work together to stimulate the creativity in one another.

The tools and techniques that are described in section 6.1 on the creation of knowledge all depend on the interaction of a group of people. Teams must be able to work together in order to utilise the group dynamics. This is becoming more

difficult with geographically dispersed project teams. The solution for this problem is the development of virtual workspaces or collaborative tools. The aim is to have people working together without them realising that they are not in the same room.

The following components are needed to make a virtual workspace effective.

a) Awareness

This describes the ability of the system to notify or enable users to find out what is happening in the workspace. Information such as, who is busy with discussions, what topics are being discussed, and where the discussion is taking place will be communicated to users. Systems use search engines to perform searches for the above-mentioned information or a user can browse through the workspace.

Collaborative Virtual Workspace or **CVW** is a software solution that makes it possible to participate in two discussions simultaneously by using a proxy. The analogy of a building with dedicated rooms for discussions makes navigation easy. Discussions that are related will be on the same floor. **CVW** also makes it possible for a user to join another user without knowing in what room the user is.

A system must be able to accommodate both spontaneous as well as scheduled discussions. Workspaces must also be persistent. This means the workspace exists even if no one is using it. This will enable participants to visit the work area asynchronously and work on the team solution.

b) Conversation

Conversation between people using the workspace is made possible in different formats. Most systems have the ability for text messaging to the group (public) or to a specific person in the group or on the network (private). It also has bulletin boards and Internet Relay Chat (IRC) facilities. These can be used for asynchronous discussion, where the participants are not participating at the same time. The more advanced systems use audio and video conferencing for synchronous communication. This is the best way of communicating and can be used in combination with text-based communication. **InfoWorkSpace**™ offers a voice-over-IP solution for audio conferencing and **Collaborative Virtual Workspace** offers non-verbal features in the messaging services they offer.

Some of the features in **Collaborative Virtual Workspace** are important for capturing the creative process. A room recorder records all public conversation. This enables a scroll-back of the text conversation that is of use to team members who are new to the discussion or have missed a meeting.

c) Shared objects

Participants in a virtual workspace must have a shared workplace. This is the area where discussions are made visual. Most systems utilise a shared whiteboard. This is used in the same way as a physical whiteboard in a physical meeting. All participants can add text or graphics to the whiteboard simultaneously. The whiteboard in a virtual workspace however can be saved. This enables participants to refer back to previous discussions by referring to the whiteboard.

Sametime Connect™ is a collaborative tool that makes it possible to convert files to whiteboard images. This can be used to edit a document simultaneously by giving participants the opportunity to add annotations to the document on the whiteboard.

The other form of shared objects is application sharing and application casting. In application sharing two or more participants are working on the same document. All participants can edit the documents, although not simultaneously. Application casting makes it possible for all participants to view the application running on the workstation of one participant. This makes it possible for people to work on the same electronic file even if the application is not installed on all workstations.

d) Document management

The fourth component of a shared workspace is a shared space for storing and sharing documents. The space should have all the functionality of a good document management system. A document management system should enable users to search for documents by file name, author or content. The system should track the editing of a document by saving previous versions and highlighting changes when required. Single user checkout of a document enables a change to be tracked to a specific user. Workflow enables a distribution chain to be established to ensure that all the relevant people review a document. An administrator or leader of the workspace can assign certain privileges and restrictions to users. This will ensure that unauthorised users does not edit or destroy important documents.

Complicated file structures can be avoided when document management is in the context of the work being performed in the virtual workspace.

The virtual workspace solutions that have most or all of the functionality mentioned above are **Collaborative Virtual Workspace** by the MITRE Corporation, **Sametime Connect**™ by Lotus Development Corporation, **InfoWorkSpace**™ by General Dynamic Electronic Systems and **Jupiter** by Xerox.

5.3.2 TECHNOLOGIES USED IN KNOWLEDGE CODIFICATION

Codification of knowledge consists of two steps: the first is to collect knowledge and the second to store it. The knowledge that is stored inside people must be mapped to enable others to find the person that is "storing" the knowledge.

Technology can be used to collect knowledge by making it easier to document and capture certain work processes.

a) Knowledge collection

When knowledge is collected or captured, thought must be given to the representation of that knowledge to the user. According to Borghoff and Pareschi (1998, p. 81) users will receive the knowledge in one of four technological spaces. The first is the physical space. This is a representation of a physical layout. Maps and facilities layout is a representation form of the physical space. This can be used as an easy reference for finding a person or object because it is related to the physical world.

The second is the social space. The social representation of information focuses on the relationship between people and roles. An organisational chart or social network map is a representation in the social space. Workflow is only possible when information is available in the social space.

The third is the technology space. This is a representation of all the technologies used in the organisation. The relationships and integration of technologies are important when the flow of information is tracked. The fourth space that can be used to represent information is the cognitive space. This representation is used for information that is not related to the physical space. Different projects that have a common technological basis are not necessarily related in the physical world, but the

representation of the technological relationship can be used to understand the reasons for the failure of some projects.

Information must be captured in such a way that it can later be represented in the format the user will find most useful. By capturing information in the incorrect format, the information can become useless. Knowledge of the future users of the information is needed to ensure it is represented in a way that will add value to the information.

The technique of fast cycle decision-making is described in section 5.2.3 as one of the skills needed by knowledge workers. This technique is based on decisions being made quickly, on limited information, with the opportunity to make changes to the original decision in time to react to market changes. It is important to clarify and document the settings of a decision when a technique such as fast cycle decision-making is used. This will ensure that all previous arguments are considered when the original decision is revised.

The IBIS (Issue-Based Information System) methodology is the ideal tool when different stakeholders, with different views, values and beliefs have to solve a problem or make a decision. This can be done with little hard data available and when stakeholders are under time pressure. Decisions and the process used to reach a decision can be captured as a way of turning tacit knowledge into explicit knowledge and even into information. These arguments are represented in the cognitive space when captured using the IBIS methodology.

The IBIS methodology is based on a simple construct that can be represented graphically. The graphical representation clarifies group discussions and is an easy way of documenting such conversations. The documented conversation can easily be followed by anyone who knows the methodology when the decision has to be revisited later.

Three constructs are used: the first is the question. This construct is used to state the problem. The second construct is ideas of how to solve the problem and the last construct is arguments to support or object to the ideas.

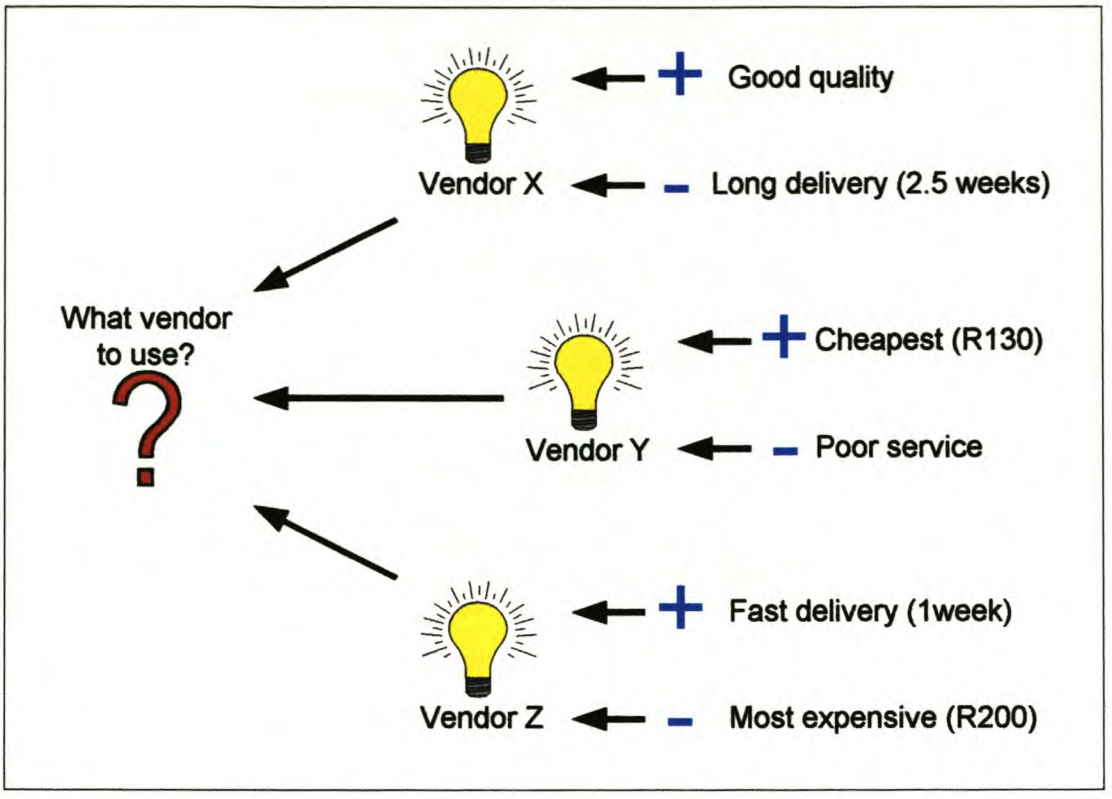

Figure 14 The IBIS Methodology

Figure 14 is an illustration of how a question is answered by ideas using the IBIS methodology. These ideas are then connected to arguments. It is also possible to have new questions that challenge the arguments. In this way a conversation to solve a problem or make a decision can be recorded, and all stakeholders will communicate without misunderstanding. People often argue the same point in group discussions but use different words. Agreeing on the wording and breaking down conversations can prevent this miscommunication.

The **QuestMap™** system is a software tool that simplifies the documentation of arguments when using IBIS. Because decision-making is one of the most important activities in projects, it must be documented in detail for future reference. By using **QuestMap™** the decision making process, with all the assumptions and the alternatives that are explored, can be stored electronically and can be used as a framework for describing the project to new members.

In order for knowledge to have real significance it must be collected and stored with reference to the context of the activities that created the knowledge. This is another

reason for using a tool like **QuestMap**™. The argument is documented while the activity of argumentation is happening.

Another way of capturing knowledge in project organisations is through lessons learned. This is often done in review or post-mortem meetings in an unstructured fashion. Structure is necessary to capture the context in which the lesson was learned. Too much structure can however make the lesson too specific and prevent it from being made applicable to other situations.

The structure used in the case based reasoning tool **SolutionBuilder**® by Primus Knowledge Solutions Inc. can be used as a guideline when capturing lessons learned. Case based reasoning or CBR is used mostly in customer help desk situations. This implies that a limited number of problems can be resolved by capturing the problem and the solution and reusing it later. CBR is relies on the assumption that a given problem can be solved by the same solution that was applied successfully to a similar problem. This is not applicable in projects that are of a unique and mostly non-repetitive nature; the lessons learned in these projects will however be repeated when a similar situation occurs.

In order to reuse the lesson it is important to know the problem that gave rise to the lesson. The problem in **SolutionBuilder**® is framed with the following statements.

- The goal or task that the project team member was trying to accomplish, but could not perform.
- A fact about the technological environment or process used by the team member.
- A symptom of the problem or a sign that something was not right.
- A recent change in the technological environment or process used by the project team member.
- A likely cause of the problem.
- A negation or a fact that is clearly irrelevant to the current problem.
- The fix or lesson learned from the problem.

By framing the problem, it can easily be linked to similar problems, and the solution can be used in future situations.

These are two of the technologies that can be used to collect and represent knowledge in project organisations. The storage of all other documentation is also

recommended but as that is the domain of information management it is taken as a prerequisite for effective project management.

No technology can be used successfully for knowledge management if the foundation of data and information management is not available. Because knowledge management is aimed at mature organisations as a further way of finding competitive advantage, it is assumed that such organisations are already using information management to its full potential.

b) Knowledge storage

The storage of knowledge once it is captured part of knowledge codification in this model. With the development of better search engines and hypertext links it has become less important to have a structure for knowledge storage. Powerful search engines can index the content of millions of documents and users can find the relevant information by using filtering techniques. The use of hyperlinks can also connect pieces of information that are logically far removed.

More important than structure for information and knowledge storage is the reliability of the storage technologies used. Morey (1998) gives the following characteristics of successful knowledge management architectures.

A knowledge store must be available. This means that if knowledge exists, it must be available to the user for retrieval. Accuracy in retrieval is to ensure that if knowledge is available, the correct knowledge is retrieved by the system. Effectiveness focuses on the usefulness and correctness of the knowledge. A system that is loaded with incorrect knowledge is more dangerous than a system with no knowledge at all. Knowledge must also be accessible to a user during the time of need. Knowledge delivered late is of no use in a fast changing environment.

The storage of tacit knowledge, that is knowledge still in the heads of people, is more a question of having a map available of the location of the *"flesh and blood"* stores. The name usually given to such a repository is *white pages*. The idea is to catalogue the experience, training and knowledge of all the individuals in the organisation and make the catalogue available with a search engine. The effectiveness of such a system is however dependant on the knowledge-focused culture and the catalogue being updated regularly.

People can be motivated to advertise their skills and experience by attaching an incentive to the amount of detail entered into the white pages. It is also important to catalogue the professional contacts of individuals both inside and outside the organisation and map the knowledge networks they use. Social networks will be discussed in more detail in section 6.3 on knowledge distribution.

5.3.3 TECHNOLOGIES USED IN KNOWLEDGE DISTRIBUTION

Distribution of knowledge is the area where technology can be used in the most effective way. With the widespread use of electronic networks people have been exposed to more information than can be used. The aim of using technology in the distribution of knowledge and information is to expose people to the smallest amount of relevant information that can help them in performing their daily work without overloading and confusing them.

Distribution can be achieved in two modes of delivery. Active distribution delivers relevant information to the user without the user actually demanding it. The user will not always know the source of the information or the mechanism of delivery, but will find the information useful and relevant. Passive distribution depends on the user demanding information and performing some act to initiate a search for the relevant information. The terms active and passive do not describe the involvement of the user, but rather the state of the distribution system.

a) Passive distribution

The well-known search engines used on the World Wide Web are examples of passive distribution of information. The information is stored passively on a file server somewhere and is only delivered to the Internet user once a search for the information is initiated. The obvious drawback of this is that a user must have an indication of what keywords or attributes of the information will result in a successful search.

Search technologies are based on the principle of matching some user input to a reference in a document or piece of information. The first part of the operation can be made more effective by supplying the user with a browseable list of keywords related to some structure that is in turn related to the context of the information for which is searched. In the search for weather data, the structure can be related to the

geographical area of interest to the user. The user will still need to know to what relative area the information is related.

The matching of information to the user input can be made more effective by using filters. The advantage of using a filter is that information of lesser relevance is removed. This can however also exclude information that is only of marginal importance according to the filter but can be useful in the creative process of the user.

The filters used in active distribution of knowledge will be discussed in the next section. These filters are also applicable in passive distribution and must be included in the search engines used by an organisation. The Internet bookstore **Amazon.com** makes use of filters for both active and passive distribution of information. When searching the site for books, the filters are used to recommend books that were bought by other people with similar profiles. The company also sends e-mails to specific profile groups with special offers that are relevant to the profile group.

The last part of the passive distribution operation is the matching of information to the user input. Advanced search engines use indexes of words to reference the content of documents. The content of all files within a defined storage boundary is matched to the index. The search string is made up of words from the index, and all matches or combinations of matches are delivered to the user.

The boundaries can be internal to file servers and Intranets or can include the World Wide Web. Organisations can typically define the boundaries to include all news services on the Internet, and the web spider of the retrieval ware will index these services and deliver information from them to corporate users.

By combining a thesaurus and an algorithm for finding similar sounding words, these engines can find information that is not even exactly matched to the user input. The addition of the algorithm also makes it possible to search documents that were optically scanned and converted to searchable text using Optical Character Recognition (OCR) technology. The errors made by these technologies will not prevent a match from being made.

A passive knowledge distribution system will only be successful if users have a starting point or keyword to initiate a search. This is usually a very time consuming

process, as refinement of the search is often necessary. The greatest drawback of passive knowledge distribution is that users need to initiate a search. If a search for relevant information and knowledge is not initiated, it will not be brought to the attention of the user. Active distribution delivers relevant information and knowledge to the user, who can then decide whether to use it or not.

b) Active knowledge distribution

The two technologies that will be discussed under active knowledge distribution are the **Knowledge Pump** and electronic circulation folders. The Xerox Research Centre Europe (XRCE) developed the **Knowledge Pump** concept and software. The purpose of the **Knowledge Pump** is to get the right information to the right people in a timeous fashion.

The Xerox **Knowledge Pump** works on the principle that people with similar interests will need similar information. The software will automatically send information recommended or rated by a person to others that have similar interests, or that have indicated that they want that type of information.

The three components of active knowledge distribution are the recommendation or rating of information, the selection of the distribution list for a specific piece of information, and the method of delivery to all the users.

The recommendation or rating can be done either manually by the users or automatically by the system. The system needs some criteria to measure the importance of a document to a specific person. One of the criteria used with web pages is the length of time spent on the page. The argument is that a person will quickly browse past an unimportant piece of information and will take longer to read important information.

The automatic rating of information will ensure that all information that has been viewed will be rated. The user can however not indicate if reading the piece of information was of any use.

Manual rating and recommendation is used in the Xerox **Knowledge Pump**. This gives the user the opportunity to rate the piece of information on a five-point scale, to add comments and to recommend it by adding the name of the reviewer to the recommendation. This adds value to the information, because it is now attached to

the reputation of a person. Other users that know the reviewer or recognise the name will know how dependable the rating is.

The users will still have to be convinced to use the system and make recommendations. The recommendation and rating system must be seamlessly integrated with all applications. This will ensure that users do not waste time in making recommendations. The system must also ask as little input from the user as possible. It is important to note that certain pieces of information, such as newspaper articles have a very short life span. Users will not want to spend a large amount of time recommending a piece of information that will only be relevant for a week.

Users must be informed that their participation and interaction with the system improves their own profile within the active distribution system. This will ensure that they will receive information that is more relevant. By recommending information, the name of the user is distributed throughout the organisation. This will help in forming a reputation among colleagues. This reputation will in turn give a person bargaining power in the knowledge market.

The last way of motivating users to participate is to give feedback on use. The **Knowledge Pump** developed by Xerox gives continuous feedback through flow meters. These indicate the inflow of recommendations per person per week for the individual user and the community. The outflow is also monitored and is measured as the number of recommended links followed per person per week for the individual and the community. The user can be forced to maintain a certain ratio of inflow to outflow by attaching an incentive to it.

The second important component of active knowledge distribution is the filters used to determine what information is sent to what users. Borghoff and Pareschi (1998, p. 38) describe three possible filters. The first is personalised content filtering. This filter builds a user profile through inputs from the user in a registration form or from automatic derivation and refinement from usage data. It is recommended that both methods be used. The user will input interests and preferences and the system will refine this with the use of statistical learning algorithms.

The second filter is collaborative filtering. This filter will match users to others with similar profiles. Information recommended by a user will be forwarded to others with

a similar profile. This ensures that people with similar interests share information without knowing each other. Through this it is possible to find people in the organisation who are working on similar work and expand the knowledge network. Because knowledge is mostly resident in people it is important to connect people who can share knowledge. Collaborative filtering is a very effective method to do this because people will be connected through their profiles, without prior knowledge of each other.

The last proposed filter, and the one used in the Xerox **Knowledge Pump,** is called community-centred collaborative filtering. This filter depends on the communities within an organisation. The network of social relationships can be used as an input of communities into the system. Information recommended by a person is forwarded to all the members of the communities to which the reviewer belongs.

It is proposed that all three filters be used to ensure only relevant information reaches a person. Because the first two filters need a large amount of usage data to become effective, the community-centred filter should have a higher priority at start-up of the active distribution system.

The filters will work in the following way. Correlation between the reviewer and the other users are calculated for all three filters. A weight is specified for the importance of each of the filters. A total relevance is calculated and all matches with relevance above a specified limit is forwarded to the relevant users. In Table 5 it can be seen that the total relevance is greatly influenced by the weighting of the three filters. The information in this example would have been forwarded to user 1 and user 3.

Table 5 Example of a user matrix in an active distribution system

User	**Communities** {R,S,T,V,X,Y,Z}	**Community correlation** **Weight [50%]**	**User profile correlation** **Weight [30%]**	**Correlation with personal filter** **Weight [20%]**	**Total relevance** **Lower Limit 70%**
Reviewer	X,Y,Z				
User1	X,S,V	100% [50%]	20% [6%]	70% [14%]	70%
User2	S,R	0 % [0%]	50% [15%]	10% [2%]	17%
User3	Z,T	100% [50%]	90% [27%]	40% [8%]	85%
User4	Y,R,V	100% [50%]	30% [9%]	0% [0%]	59%

The last component in an active distribution system is the delivery of forwarded information to users. The **Knowledge Pump** developed by Xerox does this in the form of a recommended reading list that is updated on a daily basis. The user receives a personalised summary of the most relevant information that was recommended the previous day. The **Knowledge Pump** includes the rating, comments, name of the reviewer and a hyperlink to the piece of information in this summary.

The greatest advantage of active knowledge distribution is the cross fertilisation that is achieved when relevant information reaches a user in a different functional group from the reviewer who can use it in other applications.

The other way to actively distribute knowledge is with electronic circulation folders. These can be set up to be either project specific or community specific. The folders contain information that is relevant to the people on the distribution list and is forwarded automatically from one user to the next. The administrator of the folder can monitor the progress of the folder and can see when a user is not completing the use of the folder fast enough. This is very handy when documents need to be approved or modified by several people. It is recommended that circulation folders be used in conjunction with an active distribution system for circulating documents when the stakeholders are known.

Borghoff and Pareschi (1998, p. 101) describe the development and functionality of electronic circulation folders in their book **Information Technology for Knowledge Management**.

5.3.4 TECHNOLOGIES USED IN KNOWLEDGE USE

The most common technique or technology utilised for better use of knowledge is data mining. Data mining is a technique used for problem finding or knowledge discovery. Data mining transforms data into information. Knowledge is then used to act on this information to the advantage of the organisation. According to Thierauf (1999, p. 95) data mining uncovers hidden patterns and provides trends, which can be utilised to benefit the business.

Data mining will typically uncover the following five types of information.

1. Forecasting is a form of prediction that estimates the future value of continuous variables based on patterns within the data.
2. Association describes data instances that are linked in a single event. For example sales data might show that when potato chips is bought at a super market, 60% of the time it is combined with a sale of some kind of soft drink, except when a promotion of soft drink is going, then it is around 80%. This information can be used to determine the success of promotions.
3. Sequences show that events are linked over time. For example, if a house is bought, 60% of the time a new oven is bought within three weeks.
4. Classifications are patterns that recognise the group an item belongs to by examining other items that have already been classified into the group and then assigning an item according to a set of rules.
5. Clustering is related to classification, but no groups have been identified. The tool will thus discover groupings within the data.

Data mining will most often be used in conjunction with data warehouses. Data warehouses are central databases with decision support data from distributed database sources. This central database is updated at intervals from the operational databases.

Because this data warehouse contains data from different operational databases, it is important to import and structure the data in the proper format. The knowledge of people is of importance in data mining to structure the data, to interpret the information that is uncovered by the tool and to make a decision based on the information.

The following table from **Knowledge Management Systems for Business** (Thierauf, 1999) contains some of the typical data mining techniques often used.

Table 6 Typical data mining methods (Thierauf, 1999)

Data Mining Method	Advantages	Limitations
Neural networks. Programs that mimic the brain's ability to learn from its mistakes.	Usable even when relationships among variables are unknown. Models non-linearity and interaction well.	Solutions can be uninterpretable, and there still can be no convergence to a solution.
CART (Classification and regression trees). Branching that shows relationships in the form of hierarchy.	Handles all types of predictor variables and the resulting models are easy to understand.	Does not always find the optimum solution and develops discontinuous rules, even with continuous data.
K-nearest neighbour. A classification technique that classifies each record based on the records most similar to it in a historic data set.	Does not require equations and is easy to understand.	Requires large amounts of data for each new prediction, and needs large amounts of storage and computing power.
Rule indication. The extract from data of useful rules based on statistical significance.	Useful in the development of "If-Then" rules, which can be easily understood.	Creates non-hierarchical sets of conditions, which may overlap.
Discriminant analysis. The ability to differentiate between good and indifferent factors in the analysis.	Solutions are easy to understand and it is very sensitive at finding patterns.	Tends to work well if predictor variables are not normally distributed.
Logistic regression. Statistical modelling method to discern trends over time.	Generally, can be used on any data and rules are easily understood.	Can be difficult to model for large numbers of variables.

5.3.5 TECHNOLOGIES USED IN KNOWLEDGE MONITORING

The knowledge in an organisation needs to be monitored. The reasons for this will be discussed in section 6.5. The technologies that can be used to monitor the state of captured knowledge must be integrated with all other knowledge management technologies. The Xerox **Knowledge Pump** monitors and gives feedback on the flow of information into and out of the system. This can be used to motivate users to participate and gives management an indication of which knowledge fields are showing growth.

The **grapeVINE** software package by grapeVINE Technologies Ltd. is a technology that can be integrated with groupware applications such as **LotusNotes** to perform in the same fashion as the **Knowledge Pump**. The **grapeVINE** product monitors the

knowledge from two viewpoints. The first is a periodic analysis, which measures to what extent knowledge is being shared in the organisation. This will give an indication of the success of a knowledge management initiative.

The following are some of the typical questions asked and answered by the system.

- Which groups are contributing items? Which are not?
- Which groups are monitoring what subjects? Which groups contribute to what subjects?
- Which information resources are providing valuable items, and stimulating discussions?
- What is the extent of cross-divisional communication as indicated by items crossing **grapeVINE** domain boundaries?
- What proportion of items are the subject of discussion and escalation?

The second viewpoint for knowledge monitoring is the dynamics of knowledge sharing with regards to the knowledge itself. This will show which topics are currently debated and which are no longer of great interest. The following questions are answered by the system to monitor this viewpoint.

- What are the trends in keyword selection, both in individual interest profile and document categorisation?
- Are any discussions growing in size very quickly, highlighting an issue of great importance at the moment?
- Are there new patterns and trends in information needs, including keywords, significance and time-periods, apparent from analysing search requests?

These typical things need to be monitored in any knowledge management system. Although **grapeVINE** focuses mostly on the flow and distribution of knowledge, it is also giving feedback on knowledge creation trends.

These are the most important technologies for use in project organisations to enhance knowledge management. The aim of the study is to supply a summary of all the most important features needed in a knowledge management system. No software package offers every feature, but the technologies mentioned offer some of them. It is important for implementers of knowledge management systems to understand and prioritise the needs of the organisation and the individual users, when selecting a technology.

6. KNOWLEDGE MANAGEMENT PROCESS

The knowledge management enablers discussed in the previous section will enable and motivate workers to share and use knowledge in the organisation. The knowledge management process is the way that this will be done. It is important to note that the enablers must support the process for the knowledge management initiative to be effective. Without the enablers in place, the knowledge management process will most likely fail.

6.1 KNOWLEDGE CREATION

Knowledge creation refers to creativity and innovation. This indicates that it is important to be creative and develop new ideas, but also to be innovative and combine existing ideas to be used in new ways.

The following definition from Ruggles (1997, p. 81) describes creativity. "*Creativity, in art and science, consists of the ability to present information in a light which had not appeared before, but which nevertheless adds to a coherent pattern already publicly available*".

The second form of knowledge creation is combination or innovation. The definition for originality used by Ruggles (1997, p. 82) can also apply to knowledge creation through combination. "*Originality often consists in finding connections or analogies between two or more objects or ideas not previously shown to have any bearing on each other*".

Innovation as defined by David Gurteen (1998) is the combination of new and existing ideas and putting them into action. A new idea in itself is of little value. The act of putting it to use in a way that will enhance the competitive advantage of the organisation adds value to the organisation.

Creativity or the realisation of ideas can be either vision driven or knowledge driven. Vision driven creativity is to set a goal and then apply new knowledge to reach that goal. Knowledge driven creativity is to create knowledge and then find an application to utilise the ideas.

The ability of an organisation to grow through the generation of new knowledge is determined by a combination of the speed of technology transfer and the imitative

abilities of rivals. Technology transfer refers to the ability to transfer new knowledge or technologies from concept to cash.

A crucial strategic trade-off is between the amounts of time spent on the exploitation of existing knowledge versus time spent on developing new knowledge. Short-term gain from knowledge exploitation must be balanced by the long-term advantage of developing new knowledge in key areas of expertise.

6.1.1 BLOCKS TO CREATIVITY AND INNOVATION

All people are naturally curious and therefore creative. The creativity is however blocked in organisations by the following factors as described by David Gurteen (1998).

a) Creativity is serious business

Creativity is often thought to be a serious analytical task. New ideas are more often developed through playing mind games and daydreaming. Ikojiro Nonaka is quoted as saying: "*Given a certain context, knowledge emerges naturally. You will have to give your employees a lot of latitude, not try to control them.*" (Takeuchi, 1998) When people are under pressure to innovate, the "fun" is taken out of it and they will not be given the opportunity to explore new avenues of thought.

b) Creativity is not needed

Creativity is often thought to be restricted to brainstorming sessions with creativity as goal. Although these activities have an important role to play, all interactions with others must be used to learn, influence and make things happen. Creativity, just like learning, should not be limited to specific activities, but should occur every minute of a person's life.

c) Creativity is specialised

The perception that creativity is only needed by specialist disciplines such as research and development can exist in organisations. Creativity is needed at all levels of the organisation and new ideas and improvements are needed in all tasks.

d) Limiting Paradigms

A paradigm is a way of thinking or a mindset. Paradigms include theories, principles, values, beliefs and doctrines that are held at a subconscious level by individuals. Paradigms can be good and bad. In a good sense, paradigms are the immune system of the mind that protects it from possible bad ideas. It can however also prevent the acceptance of new ideas. This happens at a subconscious level and is therefore very difficult to prevent.

e) Inappropriate mental models

Mental models, as scientific models, are abstractions of reality. The purpose of a model is to reduce the complexity of reality to make it easier for people to relate to and affect changes in the real world.

Mental models are limiting as they apply only in specific situations. A strong belief in a limited set of mental models will limit actions and creativity. In a fast changing environment, it is essential to have access to a large set of mental models, or even to think things through from first principles every time.

f) Limitations of traditional teaching

Traditional teaching is based on the transfer of meaning through verbal and written media. It is however not very often that people can transfer meaning perfectly. More often than not in teaching, communication is not very effective and the recipient of the information makes assumptions based on the limited mental models available.

This leads to people having different models of reality, thinking they are talking to each other about the same things.

g) Inappropriate believes in absolutes

Knowledge, just as theories, can only ever be proven as incorrect. It is impossible to show that a piece of knowledge is the absolute best way of doing things. Creative abilities are severely limited when there is a belief that the current knowledge is the absolute truth or best way to do things, and that no improvements or alternatives should be found.

h) Worry and rewards and punishment

The idea that all new ideas must have some business value or relevance before the innovation stage is another major block to creativity. Trying to force people to be more creative in a disciplined way will usually backfire and only lead to creativity in finding ways to circumvent the system.

i) Fear and lack of truth

Fear of losing status through proposing unproven ideas is one of the blocks to creativity encountered most often in organisations. People prevent this loss of status by always speaking the perceived truth. This is perceived as the single right way of doing things in the organisation, although it has already been argued that there is no absolute truth and therefore no single right way of doing things.

j) Infanticide

New ideas are mostly ill formed, sketchy and full of contradictions. In the early stages of creation, these ideas are vulnerable and should be protected against attacks by others until the ideas can be developed in enough detail to determine their validity.

These blocks are most often responsible for a lack of creativity in organisations. Dialogue is one of the most successful methods to remove these blocks as they are mostly connected to the subconscious paradigms and perceptions of individuals. Takeuchi argues that tacit knowledge needs to be communicated to others. During this dialogue or communication, knowledge is created (Takeuchi, 1998).

According to Gurteen, dialogue is a tool that allows people to discuss issues in a way that helps to reveal limiting paradigms. Dialogue in groups and one-on-one can lift one of the major blocks to our creativity. According to Steven Covey, we listen "*with the intent to reply, not the intent to understand*" (Gurteen, 1998).

By suspending your own viewpoint when interacting with others, it is possible to focus on the alternative viewpoint offered by the other person. The following table from the article **Knowledge, Creativity and Innovation** (1998) by David Gurteen shows a comparison of the attributes of dialogue and discussion.

Table 7 Comparison of dialogue and discussion

Dialogue	Discussion
Non-judgemental	Judgemental
Exploring	Confrontation
Win-win	Win-lose
Synergistic	Fragmenting
Inquiring	Defending
Learning	Persuading, telling, selling
Divergent	Convergent
Creative	Destructive
Trust	Cynicism

Dialogue is an informal technique to encourage creativity and must be used by all members of the organisation. The formal techniques used to improve creativity are more focussed and more difficult to use in everyday situations.

6.1.2 FORMAL TECHNIQUES FOR STIMULATING CREATIVITY AND INNOVATION

Some of the formal techniques that can be used for creativity stimulation are briefly described below.

a) Synetics

This is defined as the joining of different and apparently irrelevant things. The idea is to find analogies between things that are in fact very different from each other. This is used to test assumptions. Specialists in fields that are very far removed from the problem at hand will have to be involved when using this technique.

b) Brainstorming

The purpose of brainstorming is to generate ideas that are unconventional and may not even be directly relevant. The steps followed in brainstorming are as follows. First, the problem or subject is written on a board. This is the focus for generation of ideas. It is stressed to all participants that the first step only involves the generation of ideas; no judgement or criticisms will be tolerated, as it impedes the flow of ideas. All ideas are written on the board. No ideas are discussed and none are left out. If an idea is repeated, it is written up again.

The next step is the structuring of ideas. The aim is to find a connection between different ideas. Because the same subject inspired the ideas, connections or themes will emerge. This can be done with the use of techniques such as cause and effect diagrams, affinity diagrams, interrelationship *digraphs* and matrix diagrams (Brassard and Ritter, 1994).

After ideas are structured and grouped, they should be rated and prioritised. This can be done with the use of techniques such as the nominal group technique, prioritisation matrices or the process decision program chart (PDPC).

This method should result in a number of ideas that are prioritised according to relevance.

c) Morphological analysis

This tool is used to ensure that all information potentially relevant to a problem is examined. All information is grouped as attributes of concepts and all combinations are examined. By examining all possible solutions, no preconceived judgements will impair the search for the best solution.

d) Lateral thinking

De Bono devised this term that describes a number of techniques that can be used to construct patterns and concepts by looking at existing data in a new way. The techniques involve exposure to randomness in the form of words randomly chosen from a dictionary or a passage randomly chosen from a book. This random stimulation is used to look at a problem in a new way.

e) Force field analysis

This technique identifies factors and forces that support or work against finding the solution to a problem. This technique should be used when there is resistance to change, or when people are unwilling to admit there is a problem. The following steps describe the process. First, write down the issue or problem. Then write down the ideal state. Now brainstorm to find the internal and external forces that drive the group or organisation towards the ideal state. Then brainstorm to find the forces restraining the ideal state, and prioritise the forces (Brassard and Ritter, 1994).

These are some of the ways to improve the creation of knowledge in organisations. It is however important to capture or codify the knowledge in the context it is created. The codification of knowledge will be discussed in the next chapter.

6.2 KNOWLEDGE CODIFICATION

Knowledge codification refers to the act of turning tacit knowledge that is resident in the heads of workers into explicit knowledge or information that can be stored and transferred to others. In this chapter the process of codifying tacit knowledge, of turning tacit knowledge into explicit knowledge and turning explicit knowledge into information is discussed.

Knowledge can be found in different dimensions. The two dimensions that are most often used are the tacit and explicit dimensions of knowledge. These two dimensions of knowledge are compared in Table 8 below (Davenport and Prusak, 1998). The codification can be made more effective by identifying the dimensions applicable to a specific knowledge object.

Table 8 Codification dimensions of knowledge

Tacit	Explicit
Not teachable	Teachable
Not articulated	Articulated
Not observable in use	Observable in use
Rich	Schematic
Complex	Simple
Undocumented	Documented

Before the process of codification is discussed, it must be mentioned that all knowledge that is codified is not necessarily of importance to the organisation. The following four principles described by Davenport and Prusak (1998, p. 69) will guide knowledge and content managers in the evaluation of knowledge.

- Managers must decide what business goal the codified knowledge will serve in the organisation.
- Managers must be able to recognise knowledge in various forms that will be used to reach the goals identified above.
- Managers must evaluate knowledge for appropriateness and usefulness before an attempt is made to codify it.
- Codifiers must identify an appropriate medium for codification and distribution.

Codification of knowledge has the advantage that the knowledge is moved from the person to the organisation. This will ensure that knowledge is not lost when a knowledgeable person leaves the organisation. Codified knowledge is also easier to transfer to others and can therefore be used more effectively.

The disadvantage of codification is that knowledge must be captured in context. This context can for example refer to a specific problem, a specific situation, a specific work activity or a specific product or service of the organisation. Knowledge becomes more explicit when captured with more reference to context. This will however limit the application of the knowledge to the specific context. The challenge in codification is therefore to capture knowledge with only enough reference to context to make it reusable without constraining people from applying the knowledge in other applications or different contexts.

An example is knowledge on solving complex design problems. The person with this knowledge can solve a multitude of problems. In order to capture the knowledge it must be constrained to specific problems, where a specific method or problem solving technique can be used. Others will more easily understand the method if it can be captured in the form of a step-wise process. This can however only be done for a limited number of problems.

This example demonstrates that the person that created the knowledge can solve a wide range of problems, but in codifying it, the knowledge loses some of its relevance and power. Determining the level of structure and context is the greatest challenge when codifying knowledge.

The codification of tacit knowledge is extremely difficult and most often not very effective. The best way to make this knowledge accessible to all the members of the organisation is to assist people in identifying the person that possesses the knowledge. This will ensure that knowledge does not lose its power in the codification process and the interaction between the people can be made easier using technology.

The mapping of tacit knowledge is as important and sometimes more important than the storage of explicit knowledge. Key knowledge areas and key people that possess this knowledge must be identified before the map can be constructed. It is

proposed that the existing social networks be used as a starting point. The advantage of using this method is that people with relevant knowledge is not modelled or mapped in isolation or without reference to the organisation. The successful use of the knowledge held by others depends in a large part on the interaction with that person. When the social network is used as a structure, it is easier to find some common acquaintance to make introductions.

The tacit knowledge map must not be a fixed organisational map, but should be updated by each member of the organisation as the knowledge in people is accessed and contacts are made. It is recommended that each organisation member should start by using the organisational knowledge map, but should then develop a personal map by adding contacts or human sources of knowledge to the organisational map.

The organisational map can then be updated periodically by combining the individual maps. This will ensure that new employees will have access to the widest possible range of contacts and will not have to start building a knowledge map from scratch.

The mapping of social networks within the organisation will be discussed in more detail in section 6.3 on knowledge distribution. The knowledge maps that are derived from these social networks should be captured in electronic form. This makes it easier to focus on a specific person in the map and use the map as an interface to a database with information on organisation members. In Figure 15 on the next page, a graphical representation of a social network can be seen. This map is focused on one person and represents his contacts for knowledge on information technology projects.

In the figure, the largest picture represents the focus of the knowledge search. The smaller pictures show contacts. With web browsers and hypertext mark-up language, it is easy to link pages containing *resumes* and areas of expertise to the pictures or photographs. If another member of the organisation is searching for knowledge on the skills of programmers in the organisation, this map will show who has this knowledge and who can be used for introduction to this person.

In this manner, the knowledge map captures the interaction between people, as well as the knowledge they share. This is a way of bringing people with knowledge together rather than capturing the knowledge in an explicit form.

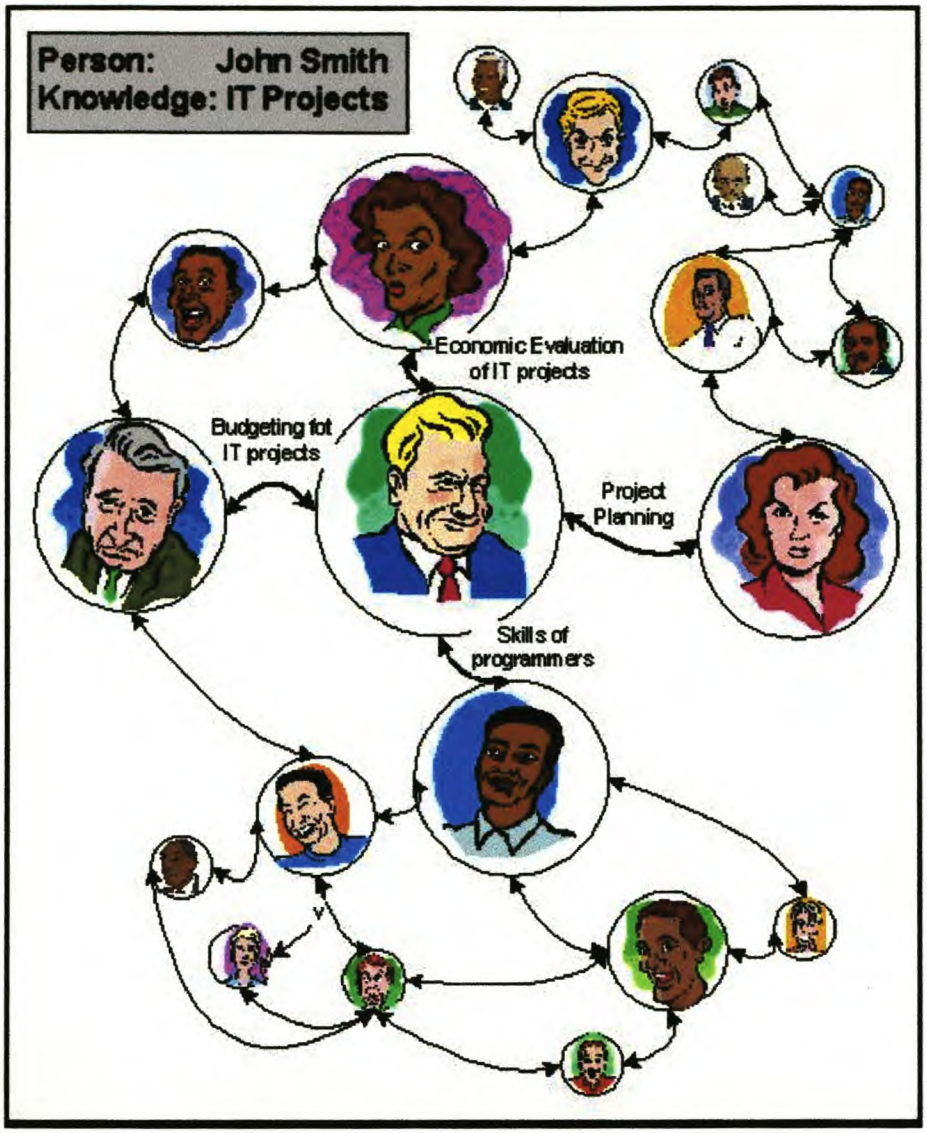

Figure 15 Example of a knowledge map

Mapping tacit knowledge with knowledge maps is a way of ensuring all members of the organisation can access the knowledge in people. It is however still important to codify tacit knowledge to protect it against loss when knowledgeable people leave the organisation. Codification of tacit knowledge into explicit knowledge is a continuous process, because people develop new tacit knowledge continuously. The following paragraphs can be used as a guideline for codifying tacit knowledge to explicit knowledge in project management organisations.

The most popular form of explicit knowledge captured in project organisations is lessons learned. The lessons learned process is a way of capturing incidents and problems that occurred in projects for future reference. The capture of lessons

learned should however not be limited to review meetings at the end of projects. Project members should capture these lessons at regular intervals as they occur. At the project review meetings, the different lessons learned can be analysed and the content experts can add the most important lessons to the lessons learned database.

The lessons learned cycle as described by van Heijst, Kruizinga and van der Spek (1996) is shown in Figure 16. The cycle describes the process of gathering lessons from the everyday work experience, analysing and storing the lessons, and then integrating it into the work processes again.

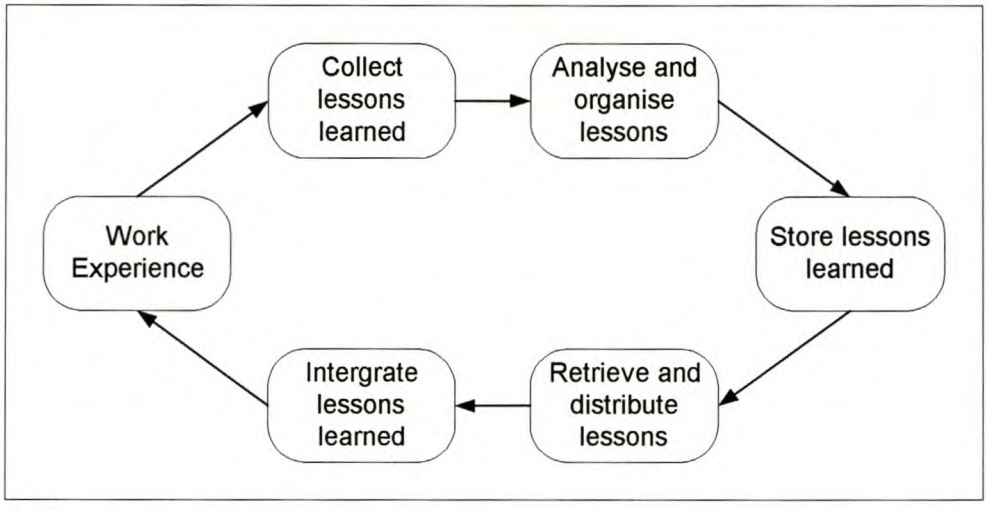

Figure 16 The lessons learned cycle

The different components of this process will be discussed briefly.

a) Work experience

Work experience describes the tasks performed in every function of the project management organisation. Important lessons are not only learned in the technical functions, but can be found in support functions as well. Knowledge must be utilised at all levels and in all functions within an organisation to ensure that the knowledge potential of all employees is harnessed.

b) Collecting lessons learned

The members of the organisation must be motivated to submit their experiences. All members will be encouraged to submit lessons by reducing the time necessary to submit the lesson. The participation of members can be measured by monitoring the number of lessons learned that was submitted by each member and accepted into

the database. This measurement should also be included into the incentive scheme of the organisation.

c) Analysing and organising lessons learned

The important thing to remember when recording or collecting lessons learned is that it must be generalised in order to be of value to a greater audience. The technologies described earlier will make it easy to record lessons learned. In the section on technologies used in knowledge codification the statements that can be used to frame lessons learned in order to capture the context of the lesson is discussed.

d) Storing lessons learned

Lessons that are classified according to the context in which it was captured can be stored in any type of repository, and will be easy to retrieve through searches using the context keywords.

e) Retrieval and distribution of lessons learned

Retrieval has become an issue of lesser importance with the advent of powerful search engines. Distribution using an active distribution system will ensure that lessons learned reach the relevant people in the organisation.

f) Integrating lessons learned

This is the most important part in the cycle. Lessons that are stored but not used to integrate into the work processes and work experience of employees are of no value to the organisation. Employees that are informed of the lessons learned by their colleagues can prevent mistakes from happening again. Once this happens, the organisation is learning from its mistakes.

Lessons learned can be a powerful source of knowledge as long as the cycle is followed to completion. Managers can determine if the investment in the time to capture lessons learned is worth the cost, by monitoring the use of lessons learned. This monitoring can be simplified with the use of the technologies recommended in the chapter on technologies used in knowledge monitoring.

The reason for the codification of knowledge is to simplify distribution of knowledge to the members of the organisation that needs it. The following section will discuss the distribution of codified knowledge.

6.3 KNOWLEDGE DISTRIBUTION

The formal structure of an organisation is set up to handle the easily anticipated and routine problems within the organisation or function. Knowledge distribution and knowledge requirements however are neither easily anticipated nor routine. The rigid organisation structure is therefore a poor channel for distributing and searching for knowledge.

The informal networks in an organisation on the other hand is formed through the natural interaction of people, and is much more useful for channelling unexpected problems and the unexpected knowledge requirements of organisation members.

Network analysis is a tool that can be used to map these networks. It is possible to distinguish between three informal networks in an organisation.

1. Advice network. This is a network with prominent technical people as focus points. Other members will call on these members for advice on problem solving and for technical information. A map of the advice network will show the most influential people in the organisation. Although these people will not always have power in the traditional organisational sense of the word, they have power of persuasion over the people that trust their judgement. This network is very useful when implementing routine changes in the organisation. This network will be used as a starting point when launching an active knowledge distribution system with community based filtering and for knowledge mapping as discussed in the previous chapter.
2. Trust network. This is a network of people that others can trust to share delicate personal and organisational political information with. The people in such a network can be trusted to back each other in a crisis in their work life. The trust network should be examined when non-routine or morale problems are encountered in the organisation. This network is of importance when the organisational culture is used to bring about organisational change.
3. Communication network. This is a network of people that regularly communicate about work related issues. The members are relatively up to date with the fields

of work with which others in the network are busy. The communication network can be used to identify and correct gaps in the flow of information.

The steps to be followed in a network analysis are described in Table 9. The sample questions for a survey are meant only as an example and should be supplemented for completeness.

Table 9 Network analysis used for mapping informal networks

Step 1	**Conduct surveys among employees and managers**
	Typical questions for a survey among employees
	Whom at work do you talk to every day? Whom do you go to for help at least once a week? With one day training, whose job could you step into? Whom would you recruit to support you on unpopular projects of yours? Whom would you trust on work related concerns?
	Typical question for a survey among managers
	Whom do you think Steve goes to for work related advice? Whom would Susan trust about work related concerns?
	Surveys best performed among upper level managers, not mentioned in this example
Step 2	**Crosscheck answers**
	Links are only kept if confirmed by both parties **The final map is a consensus by the group**
Step 3	**Process information to draw map**
	Storage as an electronic map is recommended

Once the networks in an organisation are mapped, managers can identify the following five common configurations.

1. Imploded relationships. This network configuration suggests that people in a department only have contact with others inside the same department. A solution to this is to introduce a mentor system. Senior employees introduce juniors to outside contacts. Another solution is for the company to sponsor regular "power breakfasts" with people from different departments.
2. Irregular communication patterns. In this configuration there is contact with people in other departments, and not within the unit. This could be an indication of factions within the organisation. To solve this problem it is important to talk to peripheral members of the factions, and not the leaders, to find the reason for this polarisation.

3. Fragile structures. This configuration shows that contact is only within the unit and with one other department. This can prevent effective cross-department teamwork and prevent creativity.
4. Holes in the net. In this network configuration, connections between people are absent where they are to be expected or where these connections are of importance. To rectify this situation managers can give a problem to a group that will force consultation with others. This may result in relationships being built.
5. "Bow ties". This is a network where groups or individuals depend on a single person, but not on each other. When this person leaves the organisation, these networks will collapse.

The configurations mentioned above are not correct or incorrect, but show some of the problems that can be identified through the study of informal networks. Changes in the organisation can also be tested on the map by removing certain people and see how the change affects the configuration of the informal networks.

The mapping and updating of informal networks can help organisation members to distribute and find tacit and explicit knowledge. These maps can also be used when implementing changes in the organisation structure. It is however important to note that informal networks are tools to be used by management and organisation members. The networks can however never be managed and formed according to a plan. The power of informal networks resides in the fact that the individual members of the organisation form these networks according to their needs.

When management tries to manage informal networks and force the development of relationships among dissimilar people, for organisational gain, the network will change into just another organisational structure. It is more important for managers to identify and understand the networks already prevalent in the organisation. This will enable them to manage situations that might result from a specific network configuration.

In project organisations, it is important to guard against imploded and bow tie configurations of informal networks. These two configurations are not conducive to knowledge flow throughout the organisation, and especially over functional boundaries.

6.4 KNOWLEDGE USE

Knowledge use is the area of knowledge management that is most familiar to organisation members. Most people know how to use knowledge once they have found it. People will most likely know how to use the knowledge they are searching for.

The knowledge processes used in most organisations are usually one of the following.

1. Decision-making is one of the processes in organisations that can benefit the most from the use of knowledge. Decisions made in the context of the organisational history are most easily implemented than decisions made with no reference to the background of the organisation. All decisions involve a percentage of risk. Knowledge of the issue can help reduce this risk by reducing the uncertainty surrounding the issue.
2. Planning is another process that is used extensively in project management organisations. The knowledge used in planning is usually based on experience and project history. Using knowledge of similar projects can reduce the uncertainty surrounding project plans. Planning is an important part of any job, and is not only the domain of the planning department of a project organisation. By planning all tasks, the required knowledge for performing the task effectively can be identified and retrieved in time.
3. Exploration processes aim to find new ways of achieving goals and new knowledge to be used in reaching for the goals. In exploration, meta-knowledge on the process used to explore new concepts will improve the effectiveness of the exploration. Planning the exploration process is again very important, as it will focus the search on a specific goal. Knowledge of previous successful explorations will help limit the time spent on unfeasible alternatives.

By identifying the knowledge-process that is undertaken, organisation members can more effectively search for knowledge to improve their work.

6.5 KNOWLEDGE MONITORING

Knowledge monitoring can be divided into two parts. The purpose of the first is to monitor the effectiveness of the knowledge management system. The implementation of a knowledge management initiative is not the final step in the

knowledge management lifecycle. Managers of knowledge management initiatives must monitor the levels of participation of organisation members to ensure the advantage of knowledge is continually translated into bottom line results.

Technologies can be used to simplify the task of monitoring the knowledge management process. Knowledge managers can form an idea of the return on the investment in technology by monitoring the use of the knowledge management system. It is however important to monitor the knowledge enablers that are not dependent or manifested in technology. The people and the culture of the organisation must be monitored by conducting regular audits, aimed at the role of knowledge in the work lives of employees. The organisational culture can be monitored with the use of audits such as the one by Bristow and Sandberg (1995).

Steps must be taken to remedy the shortcomings of the knowledge management initiative if knowledge managers cannot see a significant increase in the use and sharing of knowledge by people in the organisation.

The second part of knowledge monitoring is focused on the knowledge itself. The amount and quality of codified and identified knowledge in a learning organisation should grow steadily.

Knowledge managers can identify new topics of importance by monitoring the knowledge being created and shared in the organisation. This can be used to focus product or service strategies in the organisation.

The knowledge growth in the organisation must also be aligned with the business goals and strategies of the organisation. A growth in knowledge on topics that are not aligned with the business goals should either prompt a rethink of the strategy, or indicate a waste of organisational energy on peripheral or irrelevant issues.

The monitoring of knowledge and the knowledge management initiative is the most important control tool used by knowledge managers. This diagnostic tool will warn managers in advance of potential problems.

Because effective knowledge management is largely dependent on a supporting organisational culture, monitoring of the culture can prevent costly damage to the culture, which is hard or impossible to repair.

7. COMPARING THE MODEL WITH THE IMPLEMENTATION OF KNOWLEDGE MANAGEMENT AT SASOL TECHNOLOGY

In this section the implementation of a knowledge management initiative at the South African petro chemical corporation Sasol Limited is discussed. Sasol Technology is the company responsible for engineering and technology in the Sasol Limited group. The knowledge management model recently implemented at Sasol Technology (June, 2000) is compared with the model proposed in this text.

This research project was started in 1998 by the author to gather information on knowledge management. This was to be used as background for the implementation of knowledge management at Sasol. The model proposed in this thesis will be used by Sasol Technology to refine the model that is being implemented since June 2000.

7.1 INTRODUCTION TO THE COMPANY

In this section the history and future prospects of Sasol Limited and the role of Sasol Technology in the corporate entity will be described. This discussion will set the stage and be used as background for the comparison of the model that is developed in this thesis to the Sasol Technology knowledge management model.

7.1.1 SASOL LIMITED - CURRENTLY AND IN THE FUTURE

Sasol was established in 1950, and is a world-leader in the commercial production of liquid fuels and chemicals from coal and crude oil. The company has a turnover of more than US$6-billion per year, and is listed on the Johannesburg Stock Exchange (JSE) and the NASDAQ in New York.

The Sasol Group of companies comprises diversified fuel, chemical and related manufacturing and marketing operations, complemented by interests in technology development, oil and gas exploration and production. The company has developed world-leading technology for the commercial production of synthetic fuels and chemicals from low-grade coal, as well as the conversion of natural gas to environment-friendly diesel and chemicals.

Sasol also has interests in crude oil refining and liquid fuels marketing. Sasol manufactures more than 200 fuel and chemical products at its plants in Sasolburg and Secunda in South Africa as well as at several other plants abroad. Its products

are exported to more than 90 countries around the world. The group employs approximately than 30 000 people, mainly in South Africa, with about 6 000 foreign based employees (Sasol Facts 2001).

In the past year (2000), the Sasol group has acquired the German chemical company Condea. This acquisition expanded the international manufacturing and marketing capabilities of the group, but also presented the company with new challenges.

The five growth drivers as discussed by the CEO, Mr. Peter Cox, in the 2000 annual report are listed below.

- Expanding and growing the group's portfolio of higher-value chemicals.
- Leveraging Fischer-Tropsch and other unique technologies.
- Sustaining growth in established businesses.
- Exploiting a complementary upstream thrust into hydrocarbon exploration and production.
- Promoting improvement and optimisation in all business disciplines.

The implementation of knowledge management not only supports all five the drivers for growth, but is a direct result of the last driver, *viz.* the promotion of improvement and optimisation in all business disciplines.

7.1.2 THE ROLE OF SASOL TECHNOLOGY IN SASOL LIMITED

Sasol Technology is one of the seven major companies in the Sasol Limited group. The macro structure of Sasol Technology is presented in Figure 17, and shows the major functions within Sasol Technology. These functions - used to fulfil the charter of Sasol Technology towards the Sasol Limited group - are summarised below.

- Create new business opportunities.
- Provide business support and optimisation.
- Manage internationally competitive projects.
- Develop and commercialise technology and products.
- Create, safeguard and share knowledge.
- Develop, provide and utilise high-level technical resources.

- Provide strategic direction and assist with tactical issues in Sasol on:
  - Information management
  - Supply chains
  - Environmental, health and safety issues.

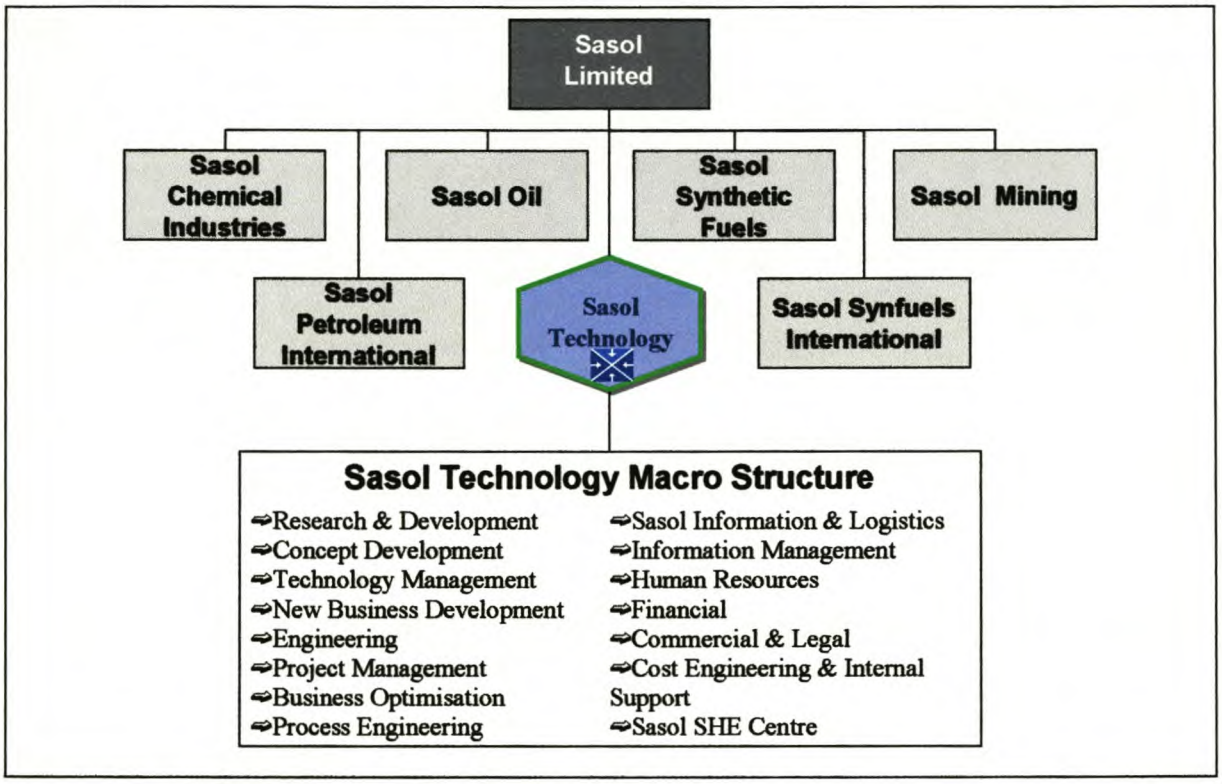

Figure 17 Sasol and Sasol Technology organisation structure

From this definition of the role of Sasol Technology, it can be seen that the focus is on developing business, technology and technical personnel and managing projects. Whereas the other companies in the group are operating companies that manufacture products, Sasol Technology can be viewed as a company that creates and uses knowledge to improve the profitability of the other companies in the group.

7.2 KNOWLEDGE MANAGEMENT AT SASOL

In this section, the decision to implement a knowledge management initiative throughout the Sasol group is discussed. It will be shown that a major strategic initiative of Sasol Limited was to improve learning and networking between employees of the organisation.

Sasol has identified several strategic drivers for the future, and in addition to these strategic drivers, five cultural drivers were also identified. Two of these cultural

drivers are learning and networking. The decision to implement a knowledge management initiative was a result of these strategic drivers; the other reasons for implementing the system are presented in Section 7.2.1. Knowledge management also supports the values of the company and in particular those of "Learning and growing".

7.2.1 REASONS AND APPROACH TO KNOWLEDGE MANAGEMENT

The implementation of a knowledge management initiative at Sasol was aimed at preventing the following items (De Klerk 2001).

- Prevent information overload.
- Prevent loss of in-house knowledge.
- Need for more creativity and innovation.
- Improve the limited sharing of best practices.
- More effective decision-making.

These reasons are similar to the reasons for the implementation of knowledge management discussed in Section 2.2 this document.

The approach followed to implement the knowledge management initiative at Sasol Technology is in the form of a strategic planning process. This approach is a popular method used for the implementation of change programs at Sasol.

From Table 10 below it can be seen that the strategic development model starts with a strategic intent at the highest level and then develops in more detail down to the level of operational action plans and budgets. The table shows each component of this model for the implementation of knowledge management at Sasol Technology. Operational plans are also developed in detail, and an example is presented in Appendix C.

The implementation strategy was developed according to the strategy development process used previously in the company, and which is a process that is well known to employees. This approach to the implementation of a knowledge management initiative has three distinct advantages.

Table 10 The strategic development model for knowledge management implementation at Sasol Technology

Strategic Intent	We Leverage knowledge to add value
Strategic Goals	To embed a culture to Network, Learn and Share to enhance our capability to add value
Strategy	• Create an environment and culture for employees to network, learn and share as part of their daily lives • Implement systems and infrastructure to make it possible to practice knowledge management • Create opportunities for employees to interact and communicate with each other to transfer knowledge
Strategic Challenges	• Encouragement of employees to populate the database of the "Bluepages" and use it to add value • Development and going live of an Intranet web site for knowledge management to enhance communication and transparency • Leverage our external contacts via a Business Contact Network • Establish a collaborative knowledge management environment through the utilisation of LiveLink • To create an environment and promote a passion for sharing, networking and learning via Communities of Practice • Build knowledge management culture vial Leadership • Measure and reward good knowledge management practices
Operational Plans & Budgets	An operational plan for each of the strategic challenges.

Firstly, the strategic importance of an initiative such as knowledge management will ensure top management support. Secondly, the initiative is rooted in the values of the organisation, therefore buy-in from all employees should be ensured. Lastly, the initiative is not hailed as something entirely new, but is shown to be something that has always been done, but will now be done more focused and effectively. This last point is demonstrated by the fact that knowledge management is implemented in a familiar way.

The approach to implementation was to develop the knowledge management implementation strategy for the Sasol Limited group, and then leave the development of operational plans and implementation of these plans to the business units. This was done to ensure that the knowledge management initiative is matched with the work processes and organisational culture of each business unit and will help to unite the different organisational cultures. The implementation of the knowledge management initiative at Sasol Technology will be examined. The reason why Sasol Technology was selected will be discussed in the next section.

7.2.2 THE ROLE OF PROJECT MANAGEMENT IN SASOL TECHNOLOGY

Sasol Technology uses the manage-by-projects approach to organise the largest portion of the work done. Research and development work is often organised as a project, as is engineering work. Although not all the work conducted by Sasol Technology is on projects, the matrix-type organisation structure of the company is typical of with the definition of a project management organisation.

Sasol Technology developed a business model, called the Business Development and Implementation Model (BDIM), which is used for the development of ideas into businesses. This model is based on a business life cycle, similar to the project life cycles discussed in Section 3.1. The BDIM is an indication of the importance of the role of project management in the approach of Sasol Technology to business development. The model also emphasises the importance of exploratory work during the first phases of the project, or Front End Loading.

It is for these reasons that Sasol Technology was selected for this study. Moreover, as the largest part of the work done by Sasol Technology is organised as projects, project management principles are therefore applied, and the model proposed in this thesis could therefore be easily compared with the model of Sasol Technology.

7.3 IMPLEMENTATION OF KNOWLEDGE MANAGEMENT AT SASOL TECHNOLOGY

In this section the implementation of knowledge management at Sasol Technology is discussed. The first part of this section discusses the model that was implemented, while the second part investigates how this model was implemented. In the last section, the knowledge management model and implementation plan for Sasol is compared with the model proposed in this thesis.

7.3.1 THE KNOWLEDGE MANAGEMENT MODEL FOR SASOL TECHNOLOGY

Knowledge management at Sasol was implemented according to the model presented in Figure 18. Although this model was used throughout the Sasol group, it was customised where required for the specific needs of individual business units.

From Figure 18 it can be seen that the model is comprised of two distinct parts. First, the enablers or enabling factors were to be implemented, followed by the second part, *viz.* the process of how knowledge management will be made actionable.

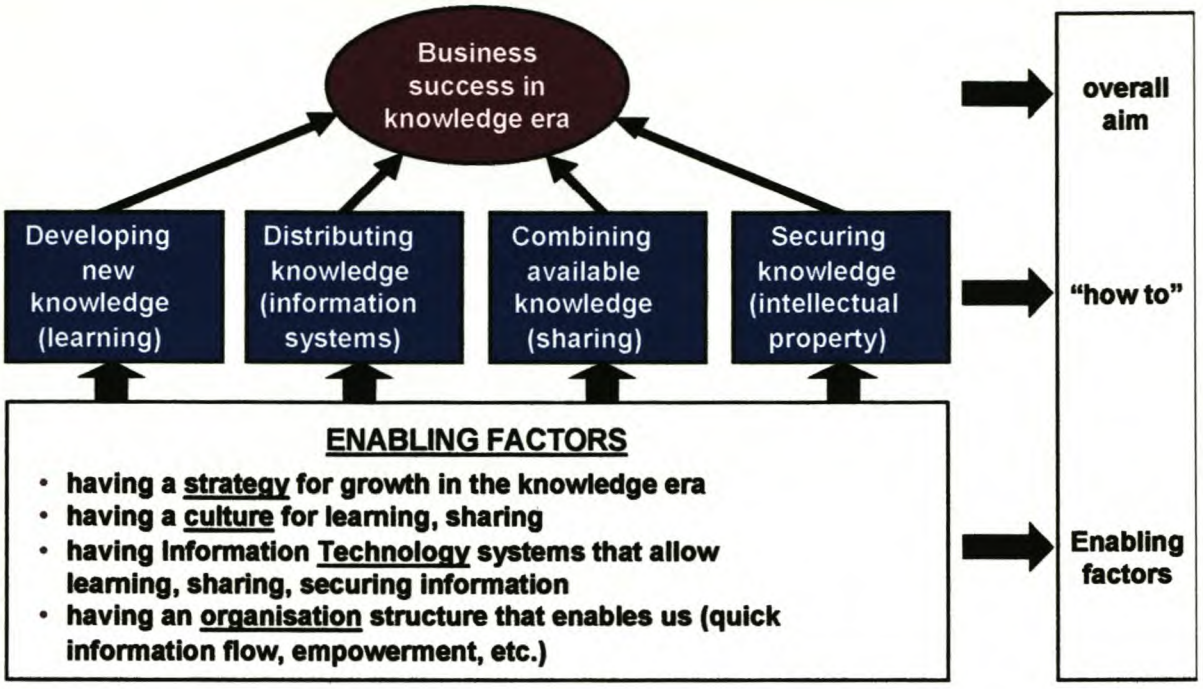

Figure 18 The knowledge management model for Sasol as presented by Mr. Jan Fourie

The enablers used in the Sasol knowledge management model are strategy, culture, information technology systems and organisation structure. In Figure 18 the process is shown to have four steps or parts. It is not clear from the figure however if the steps are consecutive or independent. These steps clearly refer to the process of knowledge management. This knowledge management process is to be individually tailored and integrated with work processes at the business unit level, as the businesses differ quite substantially.

In the next two sections the knowledge management enablers and process of the Sasol Technology knowledge management model will be discussed and compared with the model proposed in this thesis.

7.3.2 THE KNOWLEDGE MANAGEMENT ENABLERS FOR SASOL TECHNOLOGY

The *strategy enabler* refers to the strategic importance of knowledge and the effective management of knowledge in the company. This is the reasoning behind the implementation of knowledge management, and is therefore not covered in the model proposed in this thesis. Strategy as an enabler can however be important if the future strategy of the company is based on the success of the knowledge management initiative. At Sasol, the strategy enabler is included in the model to

ensure that the implementation and use of knowledge management is in line with the current strategy, and more importantly, also supports the strategy.

In Section 7.2 it was mentioned that the implementation was aligned with the strategy, and that this enabler could therefore be considered to be appropriate to ensure future actions stay aligned.

Both the culture and people enablers of the proposed knowledge management model for project management organisations are considered to be of primary importance. The Sasol enabler, *organisation*, refers to the people and structure of the organisation. The focus for Sasol is the development of organisation structures that will empower employees.

The latter is part of the organisation enabler of Sasol is similar to the people enabler of the proposed knowledge management model. The focus in Sasol is however mostly on individuals and on structures, and as Sasol Technology is viewed as a project management organisation for the purpose of this case study, it is to be expected that greater emphasis be placed on teams.

Knowledge creation and sharing is most effective when done in teams. Knowledge transfer through dialogue between team members is more accurate than when knowledge is codified and distributed. The development of a culture of knowledge sharing is also much easier when (i) done in smaller groups that are (ii) lead by people that understand the principals of knowledge management. It is therefore important for project management organisations to use project teams to its full advantage. This lack of team focus should be addressed in the Sasol Technology knowledge management initiative.

The second enabler of the Sasol Technology model focuses on the development of a culture of learning and sharing. The cultural change can be more easily realised when the components of and roles in an organisational culture are understood. The approach by Sasol is to change the culture through the example of others, especially leaders. This will however only be effective if the company understands the current culture and subcultures.

Sasol Technology employs mostly professional people. The workforce is comprised of engineers and scientists, with support personnel. The subcultures in these groups

and in different functions and projects should be studied, in order to use the culture as a vehicle for implementation.

In the model proposed for this thesis it is argued that only the employees of the company can change the culture. Employees can be encouraged to change the culture, but they will have to buy into the benefits of this idea, before they will effect changes. If the implementers of the knowledge management initiative understand the current culture in each profession, function, or project, it will be easier to get buy-in for the concept of knowledge management. Once this buy-in is achieved, employees can then be persuaded to change the culture to better suite knowledge management.

It is recommended that an organisational culture audit be conducted to identify and understand the different subcultures within Sasol Technology. Each of these subcultures can then be targeted with a specific strategy to change the respective cultures. The guidelines proposed in the knowledge management model for project management organisations could be used for this purpose. Using leaders as examples is only one of many tools that can be used.

The final enabler in both the proposed model and the Sasol model is technology. At Sasol, this is also seen as a secondary enabler, i.e. after organisation. The technology enabler is much closer to the knowledge management process, as it will enable the integration of the knowledge management process with the work processes of the company.

From the above discussion it can be concluded that the enablers in the Sasol model are similar to the enablers proposed in this thesis. It is however important to widen the understanding and use of the culture enabler, as it is the opinion of author that this is the most important enabler needed for an effective knowledge management process and for the successful implementation of the other enablers.

7.3.3 THE KNOWLEDGE MANAGEMENT PROCESS FOR SASOL TECHNOLOGY

The knowledge management model presented in Figure 18 separates the knowledge management process from the knowledge management enablers. It is noteworthy that this is also the view used in this thesis.

To further clarify differences in concepts, it is useful to distinguish between the work processes of the organisation and the knowledge management process. Work processes are used to deliver the products or services of the company, and the knowledge management process is used to ensure knowledge is managed effectively. These two processes, however, should be integrated for knowledge management to function effectively.

A major argument of this thesis is that work processes should not be changed to accommodate the knowledge management process as this will only lead to a greater resistance to the change in the company. The knowledge management processes should rather be tailored and integrated with the existing work processes without too much disruption. Once a culture of knowledge sharing is achieved in the organisation, employees can then proceed to modify the work processes to make knowledge management more effective.

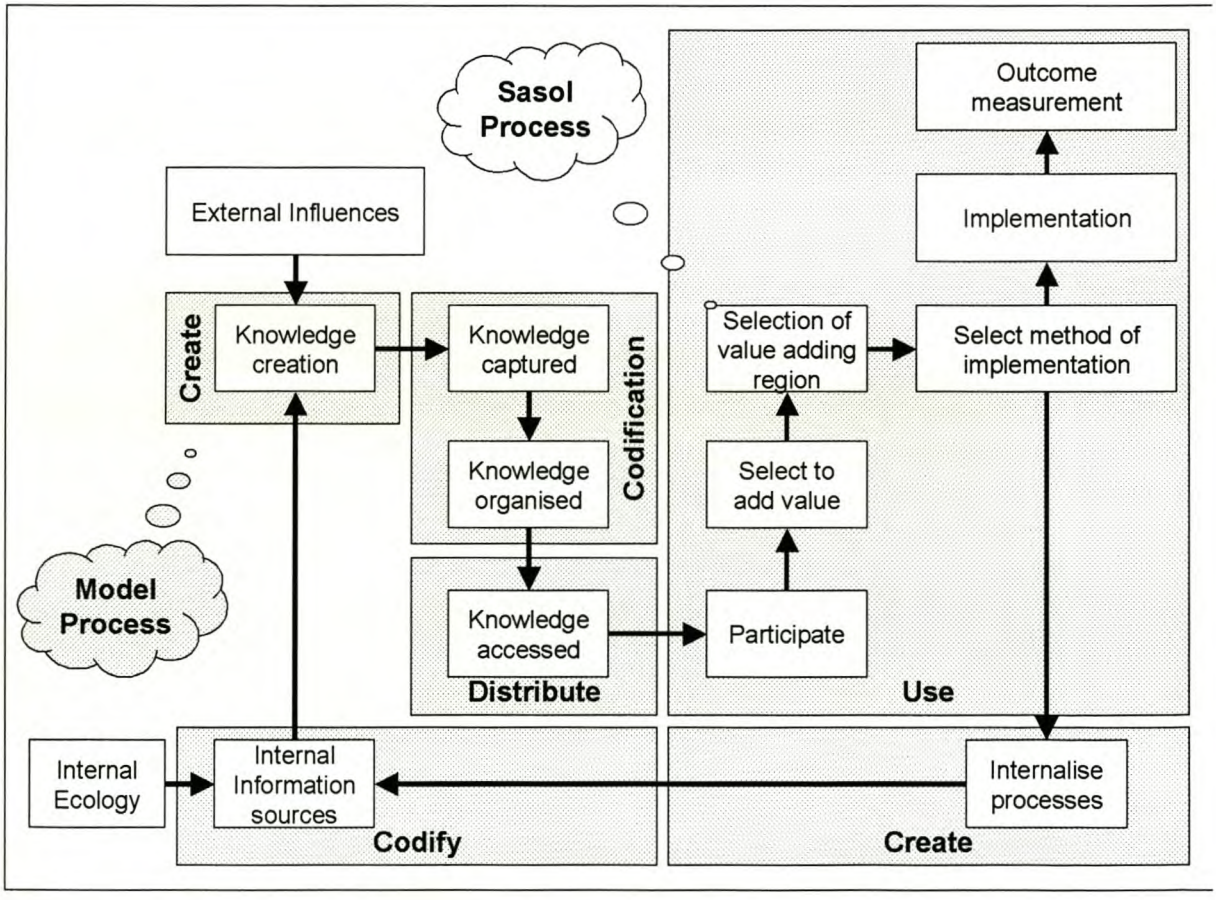

Figure 19 Comparison of the knowledge management processes

The knowledge management process presented in Figure 18 is a summary that can be described in more detail by the process presented in Figure 19 (De Klerk, 2001). This process is very similar to the knowledge management process discussed in Chapter 6 of this thesis.

The process for knowledge management in Sasol can be compared with the process proposed in Chapter 6 of this document. In Figure 19 above, a comparison is made between the knowledge management process proposed in this thesis and the process proposed by Sasol Technology. The Sasol Technology process steps are in white, while the process proposed in this thesis is coloured grey.

Although the Sasol knowledge management process is more detailed, and therefore has more steps than the process proposed in Chapter 6, the steps follow the same sequence. The major difference between the two processes however is the lack of a process monitoring or measurement component in the Sasol model. At Sasol the measurement of the contribution that knowledge management is making to the financial bottom line is of the only measurement.

Monitoring is considered to be a very important step, if only to show the return on the investment in time and money that is made to implement this initiative.

From Figure 19 the differences in the individual steps between the Sasol knowledge management process and the proposed process can be seen. However, there is no difference between knowledge creation and codification. Codification is also defined as collection or capture of knowledge, and storage or organisation. The distribution of knowledge is however only through passive distribution. Employees need to access knowledge, and it is not actively distributed. Active distribution is known to be a very effective tool to reduce information overload, and it is therefore recommended that it should be further investigated.

The description of knowledge use is very detailed, and can easily be applied to work processes to ensure that knowledge is used to the advantage of the company. It is also encouraging to see that the internalisation of knowledge, that is, the movement of knowledge from human capital to structural, is included in the model. This codification of knowledge will reduce the likelihood of knowledge loss.

The knowledge management process is not a linear process with a start and end, but a repetitive process, where knowledge use leads to new knowledge creation. This cycle is reflected in the knowledge management process of Sasol.

This process is very detailed and will simplify the integration of the knowledge management process with the work process of the company.

In the next section the plan for implementation of both the enablers and the knowledge management process at Sasol Technology is discussed.

7.3.4 THE KNOWLEDGE MANAGEMENT IMPLEMENTATION PLAN AT SASOL TECHNOLOGY

The implementation of the knowledge management initiative at Sasol was to be done in three phases. The implementation at the time of writing this thesis was in the first phase as shown in Figure 20. During this phase employees will be made aware of the advantages of knowledge management, and the cultural enabler is emphasised. In the next stage, process implementation, the focus will be on integrating the knowledge management process with work processes. During that stage the emphasis on culture will decline, while the technology enabler will only start to feature more prominently. The emphasis will be mostly on processes. During the capitalisation phase, the focus on both culture and process enablers will decline with an increased focus on supporting the process with technology.

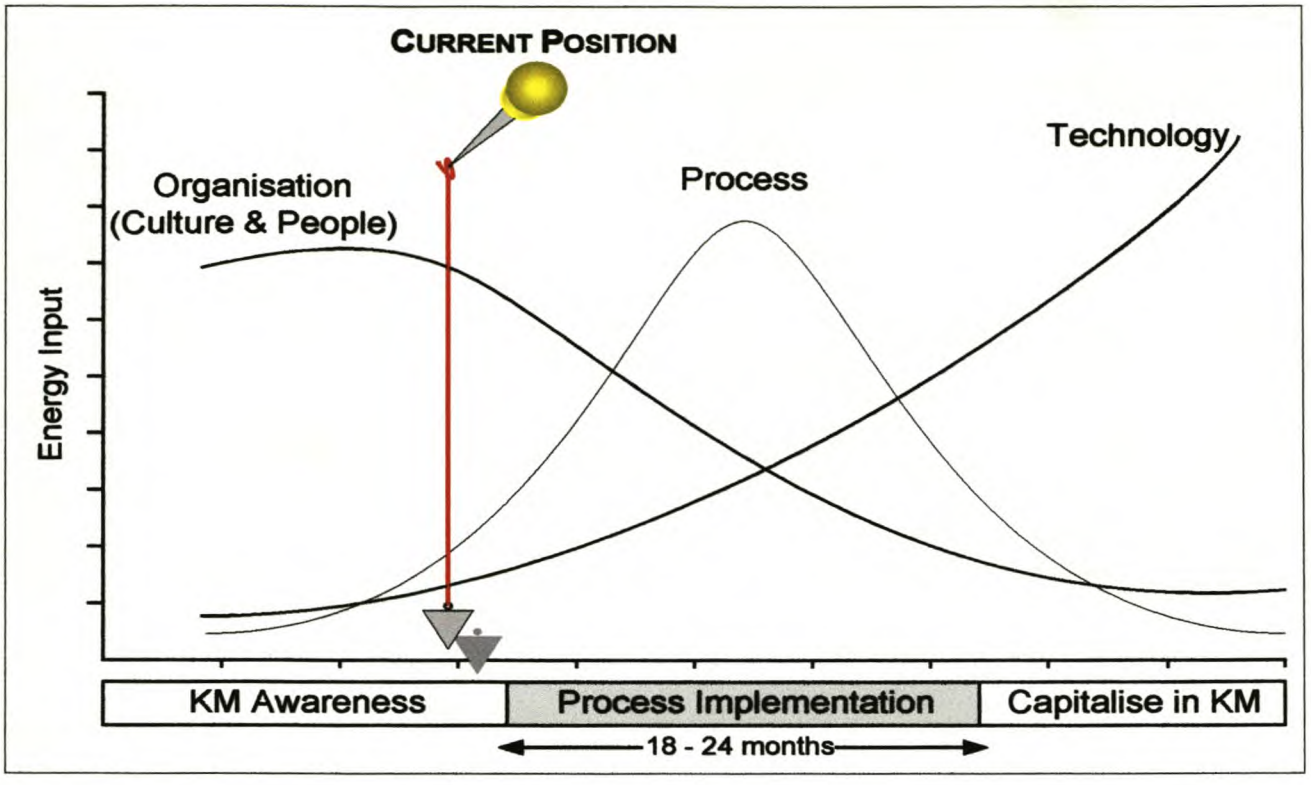

Figure 20 Energy inputs for phases of implementation

The implementation team hopes that the cultural change will have gathered sufficient momentum after phase one to allow it to continue to change positively during the later stages without additional effort from the implementation team.

The strategic challenges identified for Sasol Technology for the years 2000 and 2001, *viz.* the strategies for implementation of knowledge management are summarised in Table 10. The details for the implementation of these strategies are presented in Appendix C.

The organisational structure enabler is to be implemented using an Intranet web site for communication, building a knowledge-focused culture through leadership, and by rewarding people for knowledge sharing.

The guidelines for influencing organisational culture discussed in the model for knowledge management in project management organisations could be used at Sasol as well. First, it is important to couple the initiative to the company goals and values. This has been done at Sasol, and continued efforts should be made to communicate this to all employees. In all work discussions, with individuals and groups, this should be emphasised. Personal goals have to be aligned with the

project and company goals in order to motivate employees effectively. It is therefore possible to demonstrate to employees the benefits associated with knowledge management that will enable them to reach their personal goals and simultaneously help the company to reach its strategic goals.

This communication can only be effective if all managers, at all levels, understand the importance and principles of knowledge management. The second implementation strategy should therefore be to first educate all managers in the benefits of knowledge management. The managers can then proceed to communicate this to their employees. Knowledge management principles should be included in all training programs of the organisation. As mentioned this should start by including it in all management development programs, and later when the knowledge management process is integrated with work processes (phase two in Figure 20), this should become part of technical training as well.

These two strategies should ensure that the *purpose* and *competence* components of the organisational culture model are influenced to result in an organisational culture that will enable knowledge management.

The third strategy focuses on the adaptability component of the organisation culture model. In order to change the culture quickly, it could be appropriate to include the implementation of knowledge management with other change initiatives in the organisation. In Sasol, the integration of knowledge management processes with work processes could be included in the implementation process of the enterprise resource planning (ERP) software package SAP. This implementation has a strong focus on modelling and redesigning work processes, and knowledge management can therefore become part of this process without too much resistance.

In a similar way, knowledge management can also be made part of other initiatives. This should help employees better understand the integration of knowledge management with all business activities.

The use of leaders and influential peers to motivate employees to share knowledge is the fourth method to influence the organisational culture. As mentioned earlier, Sasol Technology depends on technical experts for leadership in technical matters. These

people have power and influence within their professions, although this is not always reflected in the formal organisation structure of the organisation.

To improve the acceptance of knowledge management, these leaders should be used to promote the advantages of knowledge sharing. This can be done through the example of exchanging knowledge with everyone that might have relevant knowledge. These people however are sometimes the most reluctant to participate in the knowledge market, as they are most threatened because their expert knowledge is perceived by them to be their only source of power in the company.

By educating these technical leaders in the advantages of knowledge sharing, they can also lead by example, and influence other technical personnel that look up to them.

The use of informal social networks for communications within the company is the last guideline recommended for influencing the organisational culture. Organisational culture is influenced by disturbing the current culture and then waiting to see what emerges as the new culture. This formation process however is very difficult to manage, as the organisational culture is distilled from the values of all the individuals in the organisation.

These inputs or disturbances must be communicated to everyone for their reactions to influence the current culture. The fastest way to communicate this disturbance to everyone is through social networks. The informal cultural roles discussed in the model for knowledge management in project management organisations can be used for this purpose. As an example, imagine that one of the most senior and respected project managers, commends a junior team member, on admitting a mistake early on, and without criticism discusses the lessons learned from this with the project team. If this project manager is to congratulate the young team member on bringing a problem to his attention, and helping to solve and prevent the problem from happening again, this manager should win the trust of all team members.

Social networks should therefore be used to distribute these stories to everyone - not only to motivate others to admit mistakes, but also to share the lesson learned from this. This is strongly dependant on the maturity of the leaders and managers in the

organisation. Managers that do not exhibit a tolerance for mistakes will not know of the mistakes until it is too late to limit the effect of these mistakes.

Managers that are competent in their abilities to prevent mistakes from being repeated, will be tolerant to mistakes. These managers understand that mistakes are expensive lessons that cannot be avoided altogether. By motivating employees to hide these mistakes, the company does not prevent them from happening, and do not get any return on the investment in *schooling fees*. If the company is to lose money from a mistake, it is important to learn as much as possible from that mistake.

These guidelines should be used to supplement the implementation plans of Sasol to ensure success in changing the organisational culture.

The implementation of technology as an enabler is planned for the third phase of implementation according to Figure 20. This will be done after completion of the integration of the knowledge management process with the work processes of the company.

The integration of the knowledge management process into the work processes is to be done at all levels of the company. Although the Business Development and Implementation Model (BDIM) is a high-level model or framework for the development of businesses, knowledge management should be integrated with this model, but also on a lower level.

All processes in the company, especially decision-making and problem solving, should be integrated with the knowledge management process. If the organisational culture supports knowledge management in the company, then motivated people on all levels of the company will drive this integration. People will be empowered by the culture to improve the way they work. The role of the implementation team will be to guide and support these people, and to ensure that the knowledge management processes in different functions are integrated.

Employees will be motivated to change the way they work, provided that they understand the advantages of this change for themselves and the company. It is therefore important that this should be communicated to everyone during the cultural change phase.

8. CONCLUSIONS

In this section the conclusions that were drawn on the extent to which the aims of the study were achieved.

8.1 CONCLUSIONS ON THE STATE OF KNOWLEDGE MANAGEMENT AND PROJECT MANAGEMENT

The literature review showed that there is a move away from the industrial economy to a global economy, and this shift is driven by information and knowledge (Clarke, 2001). From this shift a need has developed for a study of knowledge and the management of knowledge. To unlock the hidden value of knowledge, it is important that knowledge be properly managed in order to become a source of competitive advantage.

In this work the need for knowledge management in all organisations, and especially in project management organisations, was investigated. It was established that the unique nature of projects is an important attribute that necessitates the management of knowledge to improve the performance of project management organisations. Although a common model for knowledge management could not be found from the literature study, it was clear that a model could be compiled to include the most important components of the models found in the literature.

Such a general model for knowledge management, however, was considered to be not specific enough to be of value to all forms of organisations. Therefore such a model must be adapted to satisfy the specific needs of a project management organisation.

The area of project management that should be improved with the implementation of a knowledge management initiative were identified as those areas that lead to poor project performance. The knowledge management model for project management organisations that is proposed in this thesis should therefore ensure that such areas be improved upon and that the reasons for poor performance be removed.

In the next sections conclusions will be drawn regarding the ability of the proposed knowledge management model to satisfy this aim.

8.2 CONCLUSIONS REGARDING THE EFFECTIVENESS OF THE KNOWLEDGE MANAGEMENT MODEL FOR PROJECT MANAGEMENT ORGANISATIONS

From the literature study on projects, several areas of concern in projects and project management were identified (presented in Table 2) and are known to contribute to poor project performance. The model developed in this thesis will only be effective if it can rectify these issues to ensure project performance is increased.

The conclusions that were drawn regarding the ability of the model for knowledge management in project management organisations to increase project performance are discussed below. The areas of concern are first discussed, followed by a discussion on how knowledge management can increase the probability of project success.

The problems encountered in the project definition or concept phase are related to a high risk, the high risk in turn, is due to uncertainty associated with loosely defined project scope and project end-state.

Furthermore, the uncertainty surrounding the ability to control the project within budget and schedule also increases the risk associated with the project. This becomes a problem when poor cost and task duration estimates are made. An example is when the client's requirements - and therefore the project scope - are not clearly defined, therefore the end-state of the project cannot be fixed, which leads to inaccurate estimates. Uncertainty surrounding certain variables and technologies will also lead to higher risk.

To reduce the inherent risk of project failure, it is necessary to reduce the uncertainty associated with the above-mentioned issues. It is known that uncertainty can be reduced with the use of information on the issue. In projects, however, this information is not always easily accessible, but a knowledge management system should ensure that information reaches the relevant person in time to make decisions. This information can be on similar projects, or information on similar situations of high risk caused by similar uncertainties.

The effective use of this information in different project environments is dependent on the use of knowledge to relate the information to different situations. The knowledge

management model proposed in this thesis should ensure that knowledge can be more readily accessed, either in the form of documents or knowledgeable people.

To ensure knowledge will be utilised in the early phases of the project, the knowledge management system should be integrated with the project management process.

The areas of concern identified in the project feasibility phase can be improved by (i) using the organisation structure that was discussed in Section 5.2.1, and (ii) by utilising the knowledge from all functions of the organisation throughout the project life cycle. People are known to be more willing to accept advice from other functions once the culture of knowledge sharing has been established in the organisation. This should also ensure that all project decisions are based on information gathered from all relevant sources. Project team members that understand the role of others, and appreciate the contribution made by others, will be less likely to ignore important information and knowledge when making decisions.

Documentation and formalisation of knowledge and information can be improved throughout the project life cycle by a knowledge management system that is integrated with the project management process. Organisation members can be motivated by the culture to capture and exchange knowledge, and will thus ensure that more knowledge is accessible to others.

This process can be especially useful when changes in the external environment effect a late change in the project. Utilising tools such as the IBIS methodology can enable people to quickly change the direction of the project by revisiting the history of decisions.

The above arguments show that effective knowledge management could increase the probability of project success by addressing the areas of concern which were identified in Chapter 3.

The model proposed in this thesis is focused on the organisational culture and the development and empowerment of people within the organisation. Although technology can be utilised to increase the efficiency of the knowledge management process, a major finding of this work was that the two factors of organisational culture and people are critical in ensuring technology is used effectively.

Although an organisational culture can be changed to be more accommodating towards knowledge sharing and use, it must be consciously modified in order to be successful. Moreover, it was also found that too many organisations are of the opinion that organisational culture is merely expressed as the climate or level of motivation of organisation members. It is however important to first understand the structure and definition of organisational culture, and then to determine what culture will be best suited to the organisation. It is necessary to study the existing culture, and to identify areas where development and change is needed before a new culture can be embedded.

It is the opinion of this author that organisational cultures should be fostered to support the knowledge market, as well as the notion that all members of the organisation have something important to contribute in the form of knowledge and skills.

The other important enabler for successful knowledge management is people. It is the opinion of the author that people should be empowered to do their work, but also to contribute knowledge to be used by others. The definition of empowerment states that people must be willing, able, and be allowed to perform their work (Charlton, 2000). The important point is that people should not only be given skills, but they should be motivated to apply these skills and be trusted to work independently.

This thesis stresses the point that people in a project management organisation work as teams. It is therefore important that they must be empowered as individuals, but also as teams. One of the greatest barriers to learning in organisations is the culture of *punishment of mistakes* (Gurteen, 1998). Managers and leaders that punish all types of mistakes will force people to hide these mistakes or to start blaming others as soon as a mistake is made. In order to quickly learn from mistakes, it should be seen as an opportunity to improve the organisational knowledge base and should be brought to the attention of others that can learn from it. This will only happen if managers are confident that mistakes can be prevented in future.

The implementation of knowledge management must be focused on the leaders and managers in the organisation (Sarros, 2001). The change in the behaviour of these individuals will lead to a change in the behaviour of their followers.

It is the opinion of this author that project organisations should become less structured and project management less mechanistic to ensure that people have the freedom to innovate and find more effective work processes. The effective use of people and the knowledge resident in people is of greater importance than the use of systems and processes as systems and processes can usually be improved upon by knowledgeable people.

This author feels that information technology systems should be viewed as a means to simplify the capture and distribution of information and knowledge. The use of this knowledge to develop a competitive advantage for the organisation will always depend on people. People, however, must be managed to enable them to do this.

From the above arguments it is concluded that the model proposed in this thesis could be used to remove the reasons for poor performance in projects.

8.3 CONCLUSIONS ON THE COMPARISON OF THE MODEL USED AT SASOL TECHNOLOGY AND THE MODEL PROPOSED HERE

The Sasol Limited group has approached the implementation of knowledge management as a strategic initiative to address those issues that the company face in the knowledge era. As discussed in Section 7.2, the knowledge management initiative implemented at Sasol is rooted in the values of the company, and supports the accepted values of the company. The initiative is also aligned with the strategy of the company and is one of the growth drivers for the company. From these reasons it was concluded that the Sasol Technology knowledge management initiative was initiated for the correct reasons.

It was found that Sasol Technology's implementation plan is developed in enough detail to ensure that the identified strategic challenges can be addressed successfully. Fro experience it is the opinion of the author that all employees of the company are not aware of the implementation plan, and do not have enough understanding of the principles of knowledge management to easily accept it.

Communication of the plan and the desired outcomes and advantages of these outcomes should have the effect of motivating employees to participate and change the current organisational culture.

A further danger to the success of the implementation is that employees can easily dismiss knowledge management as a fad if they are not fully aware of the advantages and principles of knowledge management. By communicating the timeframe and scope of the implementation plan to everyone, employees will understand the importance of their role and responsibility in this plan.

The Sasol Technology plan is focussed on the correct components of knowledge management in the correct order. The time line presented in Figure 20 corresponds to the author's opinion that organisational culture and people are the primary enablers for knowledge management. This cultural change – so important for the successful implementation and operation of a knowledge management initiative - can then be used to implement the technologies needed to support the knowledge management process.

The successful implementation of the knowledge management initiative at Sasol, and especially at Sasol Technology, will depend largely on changing and using the organisational culture. Sasol has a proven record for implementing processes and technologies. The information technology implementation phases should be successful if the enablers of *people* and a *knowledge-focused culture* are in place.

The implementers of knowledge management at Sasol need to understand the existing organisational culture and sub-cultures in the company before the existing organisational culture can be changed to a culture that is more conducive to knowledge sharing.

The methods that are proposed in the knowledge management model for project management organisations could then be used to change the existing culture.

The proposed model for knowledge management in project management organisations includes all the components, the enabling factors and process, of the Sasol model for knowledge management. The components in the Sasol model for knowledge management that need more attention were described in this section, and it was concluded that the implementation of knowledge management at Sasol will be successful if the organisational culture is changed sufficiently.

In the next section, recommendations are made on how this research can be used specifically in project management organisations. Recommendations are also made on topics for further research in the field of knowledge management.

9. RECOMMENDATIONS

The recommendations made in this section focus on the use of the model proposed in this study based on the relevant conclusions discussed in Chapter 8, as well as further research that should be conducted on the topic to enhance the field of knowledge management in project management organisations.

The knowledge management model for project management organisations developed in this thesis is recommended as a reference framework for project management organisations that plan to implement a knowledge management initiative. It is recommended that a person tasked to implement knowledge management should appoint people that are experts in each of the *enabler* fields. These people should also understand the field of knowledge management and the impact knowledge management can have on the ability of the organisation to reach its goals.

Secondly, it is recommended that the guidelines discussed in this thesis should be used as a reference when an implementation plan is developed. A project management organisation can act to improve the project management process through the use of knowledge management if the impact of knowledge management on the reasons for poor performance in projects is understood. The knowledge management initiative should be tailored to address business problems. This will ensure that top management support for the implementation is obtained.

The third recommendation is that an organisational culture audit be performed in the organisation before and during the implementation of the knowledge management initiative. This will enable the implementers of the initiative to determine the gaps between the existing and desired organisational culture. Plans could than be developed to address these gaps. By regularly conducting audits during the implementation, the success of these plans can be gauged, and the plans can be adjusted accordingly.

A fourth recommendation is that the high-level knowledge management process proposed in this model should also be integrated with the work processes of the specific organisation. A knowledge management process that is integrated with the work processes of the organisation should be more successful than a knowledge

management process that is unrelated to work processes. An integrated knowledge management process should ensure that knowledge management becomes part of the daily work of employees, and that knowledge is generated, captured, and re-used during all work activities of employees.

Organisation members will accept the knowledge management process more easily if it is integrated with the way they currently perform their work. It is recommended that knowledge management should rather be implemented in an organisation with stable work processes. If knowledge management is implemented while changes are being made to the work processes of the organisation, the resistance to the change in work processes can have a negative impact on the knowledge management implementation. This resistance to the change in work processes could result in resistance to the implementation of knowledge management.

The second major recommendation of this work is to encourage further research in the broad field of knowledge management. The measurement of the success of a knowledge management process is currently based on the flow of explicit knowledge and information, and therefore does not report on the quality of the knowledge that flows in the organisation. Research is therefore needed to establish a method to measure the quality of knowledge flow in the organisation. This will indicate the effectiveness of the knowledge management process, as quantitative measurements only indicate the efficiency of the process.

Further research is also required on improving the measurement techniques used to quantify the transfer of knowledge between people. This exchange of tacit knowledge is usually in the form of dialogue and is therefore not quantified by the current measurement techniques that focus on explicit knowledge. In order to manage the exchange of knowledge and the effectiveness of the knowledge market, these knowledge flows need to be monitored.

As mentioned in Section 5.1, the role of organisational culture in knowledge management is of great importance. As the monitoring of this culture is very difficult, research is needed on the evaluation of an organisational culture before the implementation of a knowledge management initiative. This evaluation should answer questions on the resistance to change, the maturity of the organisational culture as well as the state of knowledge sharing in the organisation.

A method should also be developed to monitor the organisational culture during and after the implementation of the knowledge management initiative, this will enable implementers to adjust their implementation plans as required.

A greater understanding of these areas will ensure that knowledge management initiatives are implemented more effectively. Knowledge management should be embedded in the work processes and organisational culture of the organisation. Through learning and applying knowledge, the work processes and culture will change; it is therefore necessary to monitor all the aspects of knowledge management to ensure that it keeps up with changes in the organisation.

The final recommendation that can be made from this study is not to underestimate the importance of *soft issues* such as the organisational culture and people when implementing a knowledge management initiative. Information technologies can be used to automate and simplify the process of knowledge management, but the verbal exchange of knowledge between people is still the cornerstone of successful knowledge management.

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X. APPENDIX A – PROJECT MANAGEMENT INTERVIEWS AND LIERATURE STUDY

The following people were interviewed to find the most important aspects of project management that can be improved by proper knowledge management.

Name:	Dr. Pieter de Villiers	Company:	Swartklip
Type of projects:	Research & development of military arms & munitions	Years in project management:	20
Name:	Mr. Des Oswald	Company:	BSW
Type of projects:	I-commerce services, IT systems integration	Years in project management:	17
Name:	Mr. Rod Keyser	Company:	Somchem
Type of projects:	Rocket motor development	Years in project management:	17
Name:	Mr. Francois Visagie	Company:	SDM
Type of projects:	General project management, Logistics support projects	Years in project management:	17
Name:	Mr. Wulf Eilers	Company:	BSW
Type of projects:	IT systems integration	Years in project management:	15

The following literature was reviewed to find the areas of poor performance in project management.

James A Cannon (1994) pointed out the following reasons for poor performance of projects.

- Poor estimates
- Project end too hazily defined.

Frosdick and Odell (1996) named the following as the reasons for poor performance.

- Project priorities not stated

The reasons for poor performance in projects according to Iles and Hayer (1997) are as follows.

- Project end too hazily defined.

Chu (1997) had the following reasons for poor performance in projects.

- Lack of formalisation

XI. APPENDIX B – THE PROJECT MANAGEMENT LIFE CYCLE

The project management life cycle describes the project management activities from the creation of the project concept until the project is completed.

Table 11 Project management life cycles found in literature

Author	Stone (1988)	Burke (1999)	Lewis (1995)	Kerzner (1998)	Ruskin & Estes (1995)	Nicholas (1990)
Stage 1	Conception	Concept	Concept	Conceptual	Concept	Initiation
Stage 2	Development & Definition	Development	Definition	Definition	Definition & Proposal	Feasibility
Stage 3	Evaluation	Implementation	Design	Production	Planning & Organisation	Project Definition
Stage 4	Authorisation	Termination	Development & Construction	Operational	Plan Validation	System Definition
Stage 5	Detail design		Application	Divestment	Performance or Work Accomplishment	Design
Stage 6	Procurement & Construction		Post-completion		Post-accomplishment	Production
Stage 7	Commissioning					Implementa-tion
Stage 8	Operate & Maintain					Maintenance
Stage 9						System Evaluation

The project lifecycle differs among authors as can be seen in Table 11, but the following life cycle was compiled from the literature and will be used in this study.

- Project definition / concept
- Project feasibility
- Project design and development
- Project execution / production
- Project commissioning / implementation
- Project close-out.

XII. APPENDIX C – IMPLEMENTATION OF KNOWLEDGE MANAGEMENT AT SASOL

The details of each of the strategic challenges for the implementation of knowledge management at Sasol are summarised in this appendix.

BLUE PAGES

The Sasol Blue Pages is a catalogue of the skills and interests of employees in the company. In Figure 21 the layout of the site can be seen.

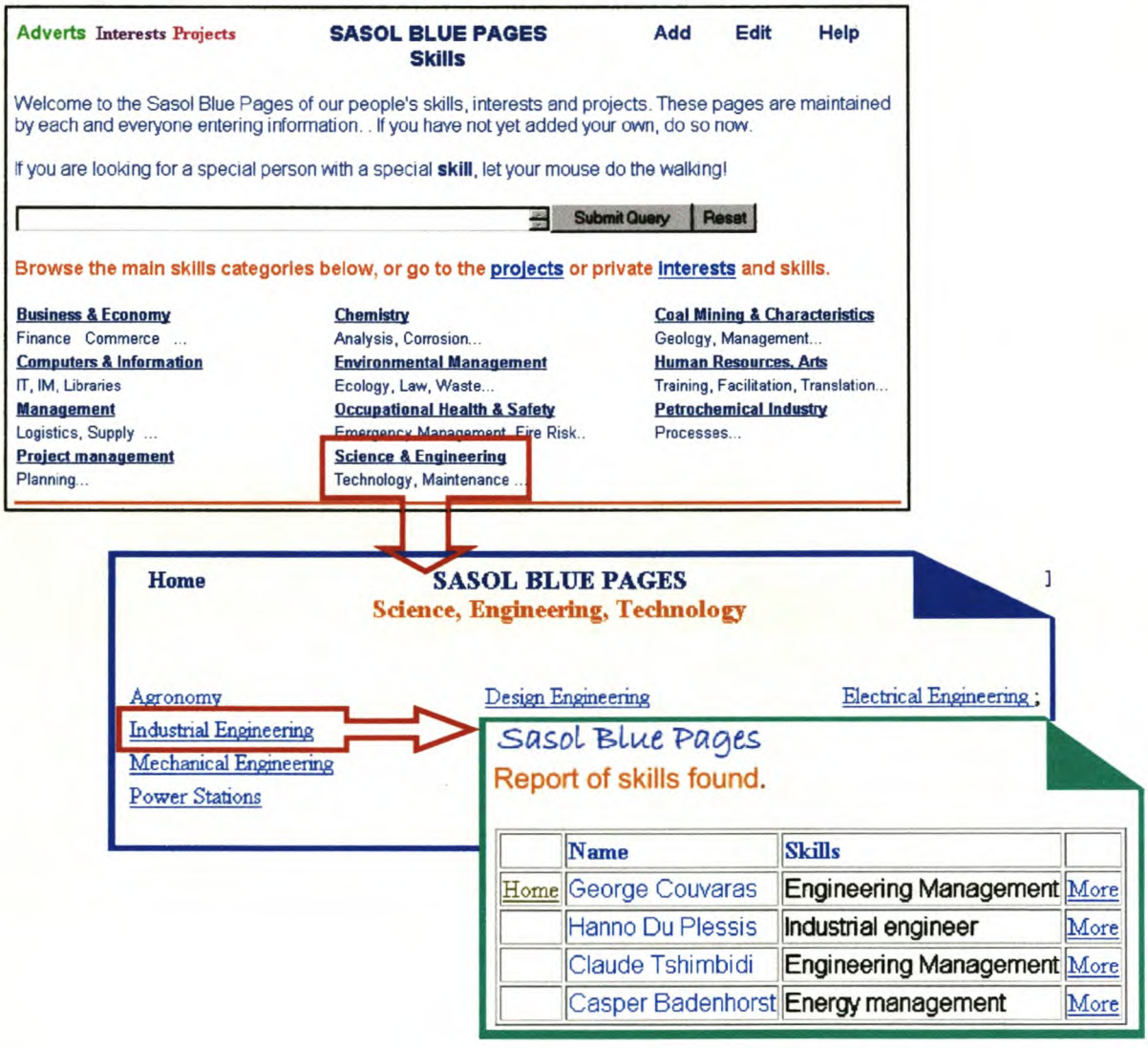

Figure 21 Sasol Blue Pages

The site that is located on the Sasol Intranet receives an average of 4192 hits per month and more than 1500 employees are registered on the system.

INTRANET WEB SITE

The Sasol knowledge management Intranet site home page can be seen in Figure 22. This site is used as a communication tool and a portal to other knowledge management sites.

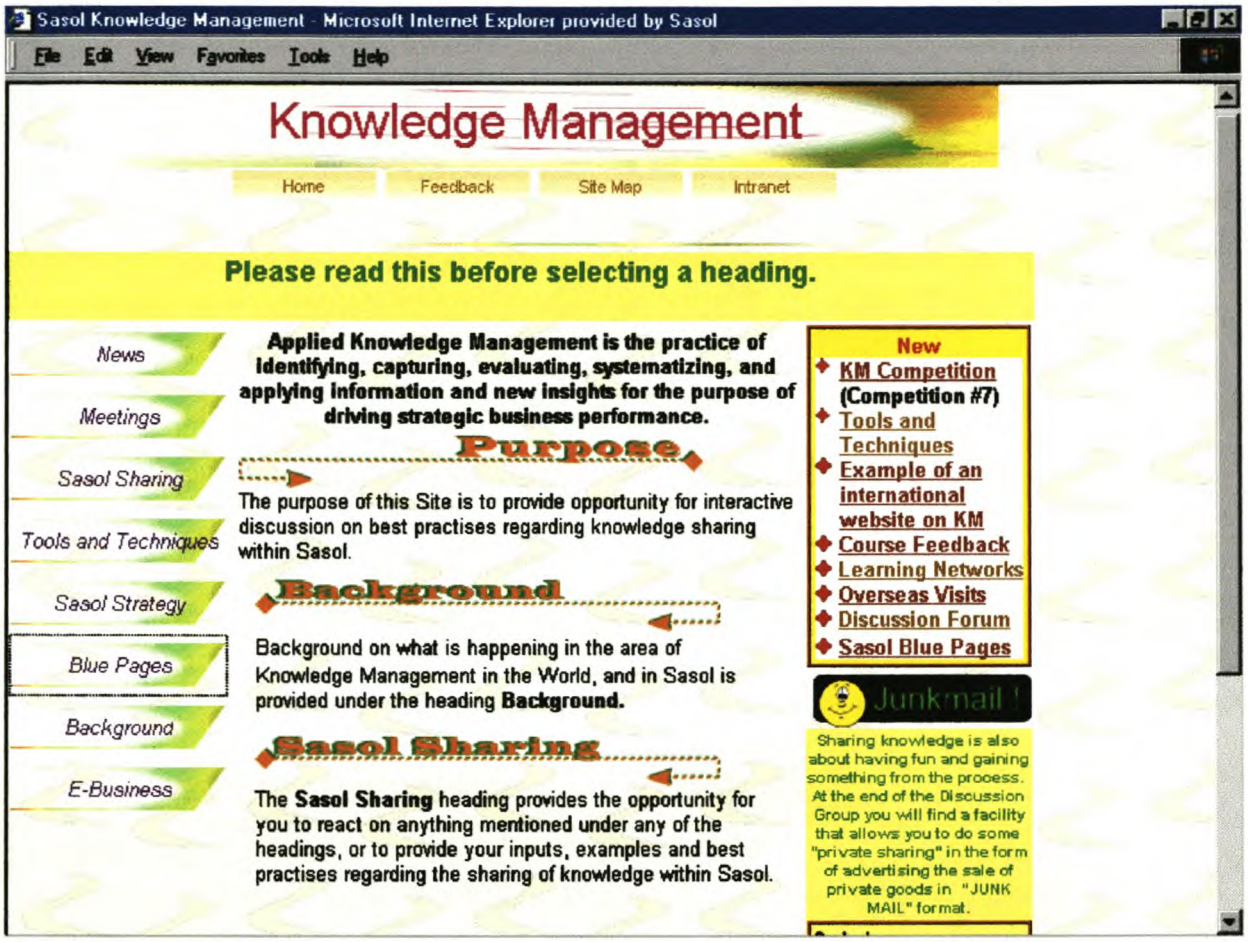

Figure 22 Sasol knowledge management Intranet site

BUSINESS CONTACT NETWORK (BCN)

The points of action for this challenge are as follows.

- Software rolled out to pilot group.
- Same software than Contact Management System.
- Improve categorisation functionality to make practical (integrate with work process).
- Continue mobilisation effort.

LIVELINK DOCUMENT MANAGEMENT SYSTEM

The document management system **Livelink™** by Open Text Inc. has been installed at Sasol. This system is used for centralised storage of documents and is used *via* web browser interface.

The company has issues 1000 user licenses to Sasol Technology and 1000 user licences has been issued to the other business units combined. For future use 2000 licenses has already been purchased.

COMMUNITIES OF PRACTICE OR LEARNING NETWORKS

Employees with similar professional interests form communities of practice or learning networks to promote discussion. The number of people in each of these communities can be seen in Figure 23.

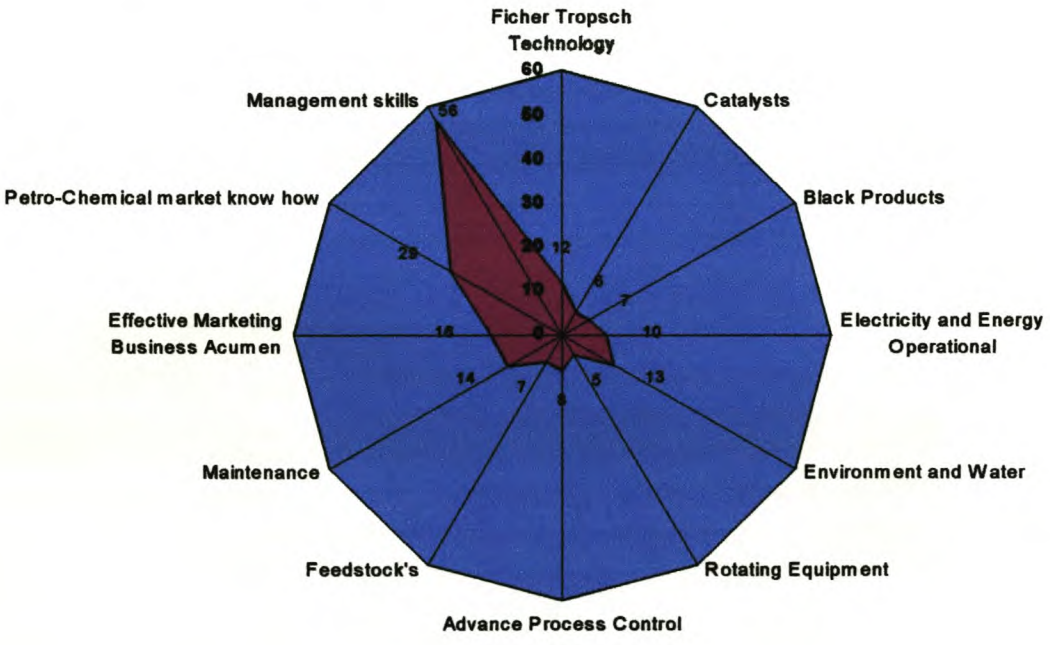

Figure 23 Participation in communities of practice

BUILD KNOWLEDGE MANAGEMENT CULTURE VIA LEADERSHIP

Leaders in the company will try to influence behaviour through their example. The desired behaviour is summarised below.

- Innovation.
- A passion for learning, sharing and networking.
- Attitude to benchmarking for improvement

- Ability to change (ability to adapt and "unlearn").
- A natural tendency to coach and mentor.
- Living the Sasol values.
- Continuously being the technology broker and custodian.
- A strong sensitivity towards intellectual property protection.

MEASURE AND REWARD GOOD KNOWLEDGE MANAGEMENT PRACTICE

Knowledge management will become part of the Sasol performance incentive scheme; whereby employees receive a bonus for performance measured against key performance indicators.

This will be included in the 2001/2002 incentive measurement year, and the details of the measurements are being finalised.